OUTLINES OF ECONOMIC ZÖOLOGY

REESE

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OF
ECONOMIC ZÖOLOGY

BY

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WITH 194 ILLUSTRATIONS

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PREFACE

While there are a few so-called "economic zöologies" on the market, there is none known to the author that makes the economic aspect of the subject the main point of attack, with morphology, habits, etc., secondary. Hence this volume which is based upon a brief course in economic zöology given by the author for several years in West Virginia University.

The book may be used in several ways. As followed by the author, the course may be given as a separate one to students who have already had the regular elementary course in general zöology. In this case the students will be familiar with the classification, structure and habits of most of the type forms discussed, but, if desired, additional laboratory work may be arranged for the study of certain parasitic and other economically important forms not generally considered in a general laboratory course. Or, the text might be used in a beginning course in zöology by some amplification of the morphologic and other aspects and considerable increase in laboratory work. Again, it could well be used as supplementary reading with, say, one hour credit per semester for the year, in connection with the regular elementary course in general zöology.

It is thought that, used in one or other of these ways or in some still different way, it should be especially useful to students in agriculture, who want a "practical" course.

Various sources of information have been drawn upon, and recognized authorities in each subject consulted so far as possible. The publications of the Government, especially those of the Department of Agriculture, have been freely used and quoted.

The figures have been borrowed largely, either from technical or from more popular works, whichever gave the best ideas of the animals portrayed; the source is indicated in every case.

The brief bibliography at the end of the book is merely to aid the student, who may have become especially interested in some animal or group, to get more detailed information.

The author is much indebted to Mr. E. W. Nelson, Chief of the Biological Survey of the United States Department of Agriculture, and to some of his specialists, for reading the proofs of this book and for various changes suggested.

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CONCERNING THE IMPORTANCE OF ECONOMIC ZOOLOGY

"In its relation to public welfare economic zoology is of the most vital and far-reaching importance. Animal life, from its lowliest organisms, among which lurk some of our deadliest foes as well as beneficent friends, to the highest vertebrates, touches and effects our lives and welfare in innumerable ways. It must be studied in all its phases as never before to guard against previously unsuspected or little known diseases of man and domestic animals, as well as to develop the wealth and ever-increasing variety of products from which we obtain food, medicines, clothing, dyes, ornaments, and an endless number of other useful articles. No man can now be considered well informed who has not a considerable knowledge of economic zoology in its more direct relationships to human life, while to the scientific investigator the subject has the charm of endless variety and service to mankind."

From an address delivered at Baltimore on December 28, 1918, by Mr. E. W. Nelson, Chief of the United States Biological Survey.

"On the whole, I think that there is no branch or stem of zoology now so important to this world as economic zoology; and in the teaching of it the vast majority of America's higher institutions of learning are fully twenty-five years behind the times.

"I have made at least six attempts to induce universities and colleges to establish chairs of economic zoology, and have failed in all save one."

From a personal letter from Dr. Wm. T. Hornaday, Director of the New York Zoological Park, written December 30, 1918.

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ECONOMIC ZOOLOGY

CHAPTER I

PROTOZOA

The phylum Protozoa includes a large number of small animals; they are mostly of microscopic size, though some of them are easily seen with the naked eye. They all consist of but a single cell, which is sometimes quite complex.

The phylum is usually divided into four classes according to the presence or absence of organs of locomotion and the character of these organs, if present. These classes are as follows:

I. **Rhizopoda**, with pseudopodia, Fig. 1. II. **Mastigophora**, with flagella, Fig. 2. III. **Sporozoa**, non-motile, in adult condition at

FIG. 1.—Ameba. *cv*, contractile vacuule; *ec*, ectosarc; *en*, endosarc; *fv*, food vacuule; *n*, nucleus; *p*, pseudopodia. Highly magnified.

least, Fig. 4. IV. **Infusoria**, with cilia. Of these classes the first three are of economic importance and will be discussed in turn, the Infusoria are of little importance, though some of them may be concerned in certain intestinal diseases.

Rhizopoda.—Without further classification several representatives of this class will now be discussed.

Ameba, Fig. 1. There are two (possibly more) species of this familiar genus that are found in the human intestine, *Ameba* or *Entameba coli*

and *E. histolytica* or *dysenteriae*. Authorities differ as to whether they should be considered as belonging to the genus *Ameba* or to a distinct genus.

E. coli is commonly found in the human intestine; as many as 60 per cent. of the feces examined in one instance, showing this species; it is apparently not pathogenic.

E. histolytica is supposed to be the cause of at least one kind of Amebic or Oriental Dysentery; and one of the first warnings one receives in going to the Orient is against eating raw fruits or vegetables unless they have been peeled or have been thoroughly washed. This entameba burrows between the cells of the digestive epithelium or, perhaps, into the cells themselves, by its ameboid activities. (*E. buccalis*, another species, is found in carious teeth.)

Rabies, or hydrophobia, one of the most fatal of the diseases to which man is subject, is transmitted, usually by the bite of a dog or some other animal. It was formerly thought that dogs "went mad" from heat, especially during the "dog days;" from having tin cans tied, by mischievous boys, to their tails; and from other causes. It is probable that animals never "go mad;" they become infected with rabies only through the bite of some other animal suffering with the disease. In the nerve cells of the brain and spinal cord of animals suffering from rabies are found, by proper staining methods, minute bodies of variable size known as Negri bodies or neurocytes hydrophobiæ, Fig. 5. If not the cause of the disease, as many think, they are, at least, a constant accompaniment of it; and it is now possible by them to tell, by the examination of the brain of the suspected animal, whether the human victim should be given the antirabic treatment or not. Formerly it took from two to three weeks to determine whether an animal were "mad;" now the determination can be made in half an hour, which is obviously a wonderful advantage in deciding whether to administer the Pasteur treatment.

Negri regarded the bodies that bear his name as Protozoa, belonging to the class Sporozoa. Other workers declare them to be Rhizopods—the class under discussion.

In the skin of persons suffering from smallpox are found small bodies that are considered by many to be Rhizopods and to be the cause of the disease. Possibly still other less well-known diseases may be due to the Rhizopods.

Foraminifera form an order of the class Rhizopods that is of some economic importance because of the limestone that is formed from the dead calcareous shells or tests, Fig. 6. One of the best known of the foraminifera is *Globigerina*. This form, which is about the size of a small pin-head, is widely distributed over the ocean, and the shells of the dead animals fall to the sea bottom where they form the so-called *Globigerina* ooze, that solidifies to form gray chalk.

Nummulites are the largest of the foraminifera, sometimes reaching the size of a silver dollar, which they resemble somewhat in shape. The pyramids of Egypt are built largely of nummulitic limestone.

Radiolaria are an order of Rhizopods having usually a complicated skeleton of silica. They are all marine forms and after death their skeletons settle to the sea floor as radiolarian ooze, sometimes hundreds of feet thick, that forms flint or quartz.

Mastigophora.—Of the pathogenic flagellata the best known genus is *Trypanosoma*, of which there are several species, parasitic in all classes of vertebrates up to man. One of the most terrible diseases to which man is subject is trypanosomiasis or sleeping sickness, which of late years has been sweeping over Africa and destroying the natives by the hundreds of thousands. It is said to be fatal in 100 per cent. of the cases, tho headway is being made toward discovering a cure.

The organism concerned is *T. Gambiense*, Fig. 2, which is introduced into the human blood by the bite of the tsetse fly, *Glossina palpalis*. Whether the protozoan undergoes a part of its life history in the body of the fly or is merely carried mechanically is a debated question; possibly there may be another and an unknown host; at any rate it has been found that the spread of the disease may be checked by cleaning up the brushy areas along streams and water-courses.

Just how the trypanosoma produces its ill effects is uncertain; it may be found in the blood, where it destroys the red cells, and in the cerebrospinal fluid. The disease, which may run its course in a few months or last for years, exhibits various symptoms, the most evident of which is a marked drowsiness or coma that has given the popular name to the disease; the patient loses all desire for food and gradually

FIG. 2.—A trypanosome; a parasitic flagellate. Greatly magnified.

wastes away and dies in a terribly emaciated condition, Fig. 3. While it is the natives of Africa that chiefly suffer, the organism attacks whites as well as blacks, and several investigators have sacrificed their lives in studying the disease.

One of the most serious and fatal diseases of domestic animal in the Orient is *Surra*. This disease is probably caused by a Trypanosome introduced into the blood by the bite of a fly.

Another serious disease of cattle in this country is *Texas fever*. The organism here, *Babesia*, is considered by some workers to be a flagellate, by others to belong to the next order, the Sporozoa.

How the cattle "caught" the disease was a great mystery until Smith and Kilborn discovered that the germ is carried from animal to animal by a tick. The adult female tick is fertilized while hanging

FIG. 3.—Victim of sleeping sickness, shortly before death. (After Calkins, *Protozoology*.)

to the skin of the ox; she gorges herself with the infected blood of her host and falls to the ground, where she lays an enormous number of eggs. Each larva, when it hatches, is supplied with a little of the infected blood; it crawls upon a blade of grass where it will die unless another ox brushes against the grass, when the young tick may succeed in attaching itself to the hair of this ox; here it develops into an adult and infects its new host the first time it feeds upon its blood. No wonder the spread of the disease was so mysterious, when one animal could infect another without ever having been within a hundred miles of it.

Sporozoa.—Of these very minute Protozoa the most important, perhaps, is the genus *Plasmodium*, of which there are probably several

FIG. 4.—Diagram to illustrate the life-history of the malarial parasite; 1, is a red blood corpuscle; 2 to 7 show the development of the parasite in the corpuscle; a, b, c, d and a', b', c', d' and e show the development of the parasite in the stomach of the mosquito; f, g, h, i, show the development in the capsule on the outer wall of the stomach of the mosquito; k is the salivary gland of the mosquito. Greatly enlarged. (After Doane, *Insects and Disease*.)

species. This is the organism that causes one of the oldest and most widely distributed diseases of man, malaria, which was the first disease that was proven to be directly caused by a protozoan parasite. Until near the beginning of the present century both the cause and the mode of transmission of malaria were unknown, though Lancisi, in 1718, ventured the statement that mosquitoes or gnats might introduce certain poisonous substances, found in swampy regions, into the human blood and thus cause malaria. It has been recognized for ages that malaria was more prevalent in damp and swampy regions and the disease owes its name—*Mal-aria*—to the commonly held idea that it was due to bad air or miasmas found hanging over swamps and such places; it was also generally thought that the disease could be contracted by drinking bad water.

In 1881 Dr. Laveran discovered a curious new parasite in the blood of malarial patients, which he claimed was the cause of the disease. This discovery did not attract much attention until some years later when Laveran and Manson independently suggested that the germ might be transmitted to man by the bite of some blood-sucking insect. After years of investigation Major Ronald Ross, of the English army, finally worked out the life history and proved that the insect responsible for the transmission of human malaria is a mosquito belonging to the genus *Anopheles*, while bird malaria is transmitted by the genus *Culex*.

The life-history of the sporozoan is essentially the same in the three types of the fever, the main difference being the different lengths of the developmental periods, the tertian fever producing the attack or chill every 48 hours, the quartan fever every 72 hours and the pernicious fever every day.

The whole life-history in both hosts, man and anopheles, is briefly as follows: the organisms are introduced into the blood when the mosquito bites. These minute, elongated sporozoa move about in the blood plasma and finally enter the red blood cells. According to some authors they do not actually enter the cells, but it is difficult to see how the following processes could take place unless they do. In the blood cells they grow and give off poisons that are contained within the cells. At the end of their developmental period, 48 hours, for example, in the tertian fever, they break down into numerous spores, and it is the escape from the corpuscles of these countless spores, together

with the above mentioned toxins, that causes the chill. This process of sporulation, which continues at very regular intervals, sets free into the blood three types of spores which, for convenience may be termed male, female and neutral. If, now, a culex mosquito sucks the blood containing these spores, they are all digested along with the blood, in the mosquito's stomach; if, however, it be an anopheles, instead of some other genus, that sucks the blood, different results follow. In the anopheles' stomach the neutral forms are digested, along with the blood, but the male and female cells conjugate and form a cyst or nodule in the wall of the stomach. This cyst breaks down into many—perhaps ten thousand—tiny sporozoites, and as there may be hundreds of cysts in one mosquito the number of sporozoites is enormous. After ten days or more these sporozoites collect in the mosquito's salivary glands, where they may live for two or three weeks, during which time, if the mosquito bite a human being she will inject into the wound some of the sporozoites, and the life cycle is begun again in another victim. Several persons may be infected by the same mosquito.

It has been found that, under certain conditions, the sporozoon may remain dormant in the spleen or bone marrow for months or years, where it can resist the action of quinine, the universally used specific for malaria; under favorable conditions it may resume its activities and the person will suffer a relapse.

Not only has this life-history of the parasite been very carefully worked out, but numerous practical tests have been made that prove very conclusively that malaria is not "caught" from mists, drinking water, etc. For example, wherever malaria is found, excepting sporadic cases that may be introduced from other regions, the anopheles is found. There are sections where this mosquito exists without malaria, simply because nobody has introduced the disease into that region. The reason for the prevalence of malaria in swampy regions is, of course, that it is in such places that mosquitoes abound.

The experiments of Grassi, the Italian, will serve as an example of many similar experiments. "In 1900 he received permission from the government to experiment on the employees of a piece of railroad that was being built through a malarial region. This was divided for the purposes of the experiment into three sections, a protected zone in the middle and an unprotected zone at each end. Those working in the protected zone had their houses completely screened and no one was

allowed out of doors after sunset except they were protected with veils and gloves. Early in the season they were all given doses of quinine to prevent auto-infection. In the unprotected zones no screens were used and everyone was allowed to go without special protection. The result for the summer was that there were no new cases of fever in the protected zone. In the unprotected zones practically all had the fever as usual."

FIG. 5.—Negri bodies or *neurocytes hydrophobiae*, in different stages of chromatic distribution. Greatly magnified. (From Calkins, *Protozoology*, after Negri.)

Yellow fever, one of the most dreaded of human diseases is now known to be transmitted by the bite of a mosquito, *Stegomyia*, just as is malaria by *Anopheles*. While the germ of the disease has not been seen there are reasons for thinking it may be a sporozoön of extremely minute size, so that a brief account of the disease may be in place here.

In 1900, during the American occupation of Cuba, the yellow fever became so prevalent there that a yellow fever commission of medical officers was ordered to study the disease. Dr. Finlay of Havana had claimed that the disease was transmitted by the bite of a mosquito, and the commission decided to prove or disprove this theory. No braver nor more useful piece of work has, perhaps, ever been done than that of the members of this commission—Drs. Reed, Carroll, Lazear and Agramonte. The crucial test was to let an infected mosquito—that is, one that had bitten a yellow fever patient—bite a non-immune person to see if the disease would thus be transmitted. Dr. Carroll allowed himself to be bitten by such a mosquito and in due time developed the disease, so that he was the first person to whom it was proven that the mosquito had carried the disease. His heroism fortunately did not cost him his life, but Dr. Lazear, who was accidentally bitten, died in a few days. Other volunteers allowed themselves to be experimented upon, and, when the conditions were right, developed the disease. It was found that it is only during the first three days of the disease that a mosquito may be infected by biting a yellow fever patient, and that 12 days must elapse before this mosquito is capable of infecting another person. It is even claimed that the mosquito may transmit the infecting power to her offspring. Various experiments like the one quoted above for malaria were tried with yellow fever. For example, a number of non-immunes lived for three weeks in a mosquito-proof house, where they were supplied with clothing and other articles from a yellow fever hospital. They even slept between soiled sheets from a bed which a yellow fever patient had occupied. None of them developed the disease. When some of these men were later inoculated they developed the disease, showing that they were not immunes.

Thus it was conclusively proven that yellow fever is transmitted by the bite of the *Stegomyia* mosquito and in that way alone. The effect of this discovery upon the health of Havana, New Orleans, the Canal Zone and other pest-ridden places, is known to all. The problem resolved itself simply into cleaning up the swamps, covering the cisterns, etc., thus exterminating the mosquitoes. The methods employed in this work will be discussed in the section dealing with insects.

The terrible mortality among the laborers, engineers, doctors and nurses, while the French were at work upon the Panama Canal, was

almost eliminated while the Americans were at work there, and the Canal Zone is now as healthy as almost any part of the United States.

Another disease that may be caused by a protozoan parasite, and is quite certainly transmitted by one or more species of mosquito is dengue or break-bone fever, common in many parts of the tropics. It is a disease that causes suffering, but seldom death.

Kala-azar or dum-dum fever is a very dangerous tropical disease that is supposed to be due to a protozoan parasite, transmitted to man by the common bedbug of India.

FIG. 6.—Tests of foraminifera, magnified about 10 diameters. (After Calkins, *Protozoology*.)

Infusoria.—This well-known and zoologically interesting class of ciliated protozoa, represented by the commonly studied form *Paramecium*, is of little economic importance. Infusorial earth, used in making dynamite, is not made up of infusoria, as might be expected, but of the tests of diatoms and other forms.

A few of the infusoria *may* be concerned in some of the intestinal diseases.

CHAPTER II

PORIFERA

The porifera or sponges are plant-like aquatic animals, all but one family of which are marine.

The typical or primary form of a sponge is cylindrical or vase shaped, Fig. 7, but in nearly all cases a process of branching has converted the simple vase into a highly complex organism or colony. In the simple sponge the central cavity opens to the exterior by a

FIG. 7.—A colony of simple sponges. $\times \frac{1}{2}$.

single, large, excurrent opening or osculum, and by numerous minute inhalent openings or pores, Fig. 7. The pores lead into more or less complicated systems of canals which are lined with vibrating flagella that cause currents of water to flow through the canals into the central cavity and thence out of the osculum. It is these currents of water that supply the organism with food and oxygen, and at the same time

remove waste. Between the outer layer of cells, the ectoderm, and the inner layer, the entoderm, is a more or less gelatinous layer, the mesoderm, in which are found the skeletal elements that give the sponge its definite form. In the commercial sponges, of particular interest here, the skeleton consists mainly of a complicated network of horny fibres of a substance called spongin, which is stiff and hard when dry, but is more or less flexible when wet.

In other sponges the skeletal elements are tiny structures of various shapes, called spicules, which may be either calcareous or silicious.

Sponges multiply asexually by budding and by means of asexual spores or gemmules; and sexually by means of ova and sperm. The fertilized ovum develops into a ciliated, free-swimming larva that later becomes attached and develops into the plant-like adult sponge.

In the ordinary commercial sponges the process of budding and branching has gone so far that it is difficult to recognize the primary vase-shaped individual in the complicated mass with dozens or hundreds of oscula and thousands of pores.

In some of the older texts the sponges were classified under the phylum *cœlenterata*, but they are now generally placed in a separate phylum. Fossil sponges are found in all geological formations from the Cambrian upward. Although found in all seas and at almost all depths, it is in tropical and subtropical waters they especially abound.

"The sponges of commerce come from the eastern Mediterranean Sea, the West Indies, and the coasts of Florida and Central America. In the Grecian Archipelago, Crete, Cyprus, on the coasts of Asia Minor, Syria, Barbary, and the Bahama Islands, sponge fisheries constitute a very important industry. The finest sponges are obtained in Turkish waters. The fishing season commences in May and closes in September or October. Diving is practised, and is carried on in a rude, primitive manner. The diver, who has no dress, siezes hold of a large stone, to which a line is attached, and sinks by means of it to a depth varying from 30 to 180 (?) feet. Keeping hold of the rope, he tears the sponges off the rocks within his reach, and places them in a net; when he secures a netful he signals by means of the rope to be drawn up.

"Modern diving dresses have been successfully introduced in some places. The West Indian trade is annually increasing, and the fishing industry gives employment to 500 boats and 2000 persons. The Bahamas and the coast of Florida are the best fishing grounds.

"Florida is the only State in the Union which has a sponge-fishery, and there it is confined to the southwestern part of the coast, along the reefs, and to the extensive rocky shoals that lie between St. Mark's and Anclote Keys. The former is known as the Key ground, with its centre at Key West, the latter as the bay ground, with its centre at Tampa Bay.

"Nearly all the sponges used in the United States were brought from the Mediterranean till 1852, when attention was called to the immense numbers that were growing in Florida waters. As soon as it was found that the quality of these compared favorably with those of Europe the merchants and fitters-out of vessels of Key West engaged very actively in the business of placing them on the market. At first the best qualities were bought from the fisherman at 10 cents a pound. As Mediterranean sponges became scarce and costly the Florida sponges came more and more into demand, and their value increased proportionately. After about 18 years' fishing on the known ground the supply began to fail. Then, in 1870, a new area of ground, larger than the old one, was discovered, and this gave a new impetus to the trade. In that year Appalachicola sent out a small fleet of sponge vessels which has since been largely increased, and the industry has been energetically pursued with good results.

"The methods employed in the fishery differ greatly from those employed in the Mediterranean. Small vessels, carrying crews of from 5 to 15 men, are fitted out for trips of from four to eight weeks on the sponge grounds. The crews are paired off into small rowboats, or 'dingies,' to catch the sponges. One man stands in the stern, skulling the boat, while the other kneels in the bottom amidship, leaning over the side, and scans the bottom of the sea by means of a water-glass. When a sponge is sighted the boat is stopped, and the kneeling man uses a three-pronged hook, attached to a slender pole 30 to 50 feet in length, to secure it. Considerable dexterity is required of both men. To cure the sponges they are at first spread about the vessel's deck in their natural upright position so that they will die, and while decomposing allow the softened animal matter to run off freely. When they have been several days in this position they are taken to the shore and thrown into the water in little pens, called "kraals" (corrals), where the remaining substance is soaked and squeezed out, after which the sponges are removed at intervals and beaten with a stick to facilitate the process.

"Although most actively prosecuted during the summer, sponge fishing is now followed more or less throughout the year, the vessels beginning their trips during January and working the different beds successively from north southward. The state of the weather greatly affects the result of the fishery. In some years it has been a complete failure, while in others it has been very profitable, always owing to the weather. As the natural beds of sponges

have become scarcer prices have advanced, so that even if a vessel does not secure as large a quantity in a given time as formerly the financial result is about the same.

"Several varieties of sponges are caught in Florida waters. They are first, sheep's wool, which sell for \$2 to \$5 a pound; second, yellow sponges, which sell for 50 to 60 cents a pound; and third, grass sponges, which are coarse in texture and not durable, and sell for 15 to 25 cents per pound. Other coarse grades are boat and glove sponges. When these are marketed they are cleaned of sand and shells, and then pressed into small bales of 100 to 120 pounds each, in which form they go to the wholesale dealers. The yellow sponge especially is subjected to a bleaching process to improve the color, but the process ordinarily employed greatly weakens the fibre.

"Owing to the rapidly decreasing supply of the finer grades and the rising price the problem of propagating sponges artificially has been taken up seriously by the United States Bureau of Fisheries. It has been found that sponges may be raised successfully both from the egg and from cuttings but, owing to the much shorter time required for the latter to reach a marketable size, the first method has been abandoned. The technical problems of sponge raising have been largely solved and there is every promise that their culture on a commercial scale can be undertaken in the near future, and that the depleted grounds will be restocked.

"In 1900 the Florida sponge fisheries employed 2225 persons, with 156 vessels and other apparatus valued at \$594,598. The product aggregated 418,125 pounds of all kinds of commercial sponges, which sold for \$567,685. To this total sheepwool sponges contributed 181,131 pounds, valued at \$483,263" (36).

Besides the above, sponges are of economic importance in that the silicious spicules of some species form large flint deposits. Negatively, certain sponges are of economic importance because of their destructiveness to oyster beds, either by smothering the oysters or by boring (certain "Boring Sponges" have this curious power) through their shells and thus destroying them.

CHAPTER III

CØELENTERATA

This phylum, which by some authors, is made to include the porifera, though important scientifically, is one of the least importance economic-

FIG. 8.—Hydrozoa. *A*, part of a colonial species, *Obelia*. 1, ectoderm; 2, entoderm; 3, mouth; 4, coelenteron; 5, cœnosarc; 6, perisarc; 7, hydrotheca; 8, blastostyle; 9, medusa bud; 10, gonotheca. *B*, free-swimming medusa of *Obelia*. 1, mouth; 2, tentacles; 3, reproductive organs; 4, radial canals; 5, statocyst. *C*, larva (planula) of *Laomedea*. *A*, $\times 10$; *B* and *C*, more enlarged. (From Hegner, *College Zoology*; *A*, after Parker and Haswell; *B*, after Shipley and MacBride; *C*, after Parker from Allman.)

ally. It includes a large number of aquatic forms, mostly marine, and mostly soft, even jelly-like, in character; they are radially sym-

metrical and have a single gastrovascular cavity. Many of them exhibit two stages—the polyp or hydroid form and the medusa or jelly-fish stage. They possess minute sting cells or nematocysts. They are usually divided into three or four classes, as follows:

1. **Hydrozoa**, Fig. 8, fresh water polyps (*Hydra*, for example); hydroids (*Obelia*); small jelly-fish (*Gonionemus*); and a few stony corals.

2. **Scyphozoa**, Fig. 9, mostly large jelly-fish, sometimes as large as a wash-tub.

3. **Anthozoa** or **Actinozoa**, Fig. 10, flower-like sea anemones, corals, etc.

FIG. 9.—Three Scyphozoa. Somewhat reduced. A, *Tessera princeps*. B, *Periphylla hyacinthina*. C, *Charybdea marsupialis*. (From Hegner, College Zoology, after Sedgwick and Haeckel.)

4. **Ctenophora**, Fig. 11, comb-jellies or sea walnuts, very transparent jelly-like forms with eight bands of comb-like, radially arranged, ciliated plates or locomotor organs. This class is often described as a distinct phylum.

Hydrozoa.—Except for comparatively unimportant sales to colleges and museums this class has practically no economic importance so far as is known; possibly they may help destroy organic waste particles in the water.

Scyphozoa.—The same may be said of this class, except that the common jelly-fish or sea nettles are sometimes a pest along bathing beaches on account of the painful effect upon the human skin of their

sting cells. Indeed, a few forms, for example, among the Cubomedusæ, Fig. 9, may produce quite serious results.

Anthozoa.—This is the most important of the cœlenterate classes. Two species were formerly, probably still are, eaten in Italy under

FIG. 10.—A sea-anemone, *Metridium marginatum*, partly cut away so as to show its structure. $\times 1$. 1, intermediate zone; 2, lip; 3, siphonoglyph; 4, gullet; 5, inner edge of gullet; 6, edge of mesentery; 7, cavity of tentacle; 8, inner ostium; 9, outer ostium; 10, primary mesentery; 11, muscle band on primary mesentery; 12, abnormal tertiary mesentery; 13, secondary mesentery; 14, tertiary mesentery; 15, quaternary mesentery; 16, reproductive gland; 17, mesenterial filament; 18, opening for mesenterial filament. (From Hegner, College Zoology, redrawn from Linville and Kelly.)

the name "Ogliole." The corals are the most important of the cœlenterates. They have practically the structure of the sea anemones but secrete at their attachment a limestone base that forms the well-known coral reefs, so dangerous to shipping in many parts of the tropics.

Occasionally, these reefs take a circular form and may form a ring-like island or atoll, Fig. 12, with an enclosed lagoon; there have been several theories to explain the formation of atolls. In many parts of the Pacific Ocean, large groups of islands, have been formed through the action of the coral polyps, and, in many places, large deposits of limestone rock owe their origin to these small animals.

The only corals that have any value as such, except for scientific purposes, are the so-called "precious corals;" they are usually of a

FIG. 11.—Ctenophora. Somewhat enlarged. A, *Hormiphora plumosa*; side view. 1, mouth; 2, aboral pole with sense organ; 3, funnel; 4, paragastric canal; 5, a ciliated band; 6, canal; 7, tentacular pouch; 8, tentacle; 9, gelatinous substance. B, *Pleurobranchia pileus*; view of aboral aspect, showing central statocyst, polar fields (Pf), and 8 ciliated bands (c.ss., c.tr). (From Hegner, *College Zoology*, A, from Shipley and MacBride, after Chun; B, after Lankester.)

bright red or pink color and are made into necklaces and other ornaments. These corals are of a delicate branching type and are collected mainly in the Mediterranean Sea, especially along the coasts of Africa, Italy, Sardinia, and elsewhere, even as far as the Cape Verde Islands. They were formerly thought to have medicinal value and to be able to ward off danger and are still worn by superstitious Italians to keep off the "evil eye."

Precious coral has been used in these ways since remote times;

the Gauls ornamented their weapons with the material until the oriental demand became so great as to use up the entire supply.

A cheap variety of precious coral is collected in Japan; it is also found off the coasts of Ireland and Australia. There is a black coral dredged in the Persian Gulf. The African fisheries have changed hands several times but are now under French control, so that non-French dredgers have to pay a heavy royalty. Previous to the French Revolution, Marseilles was the chief centre for collecting and working the coral; now Naples, Genoa and Rome are the chief centres.

FIG. 12.—A small atol. A sketch of Whitsunday Island in the South Pacific.
(From Hegner, *College Zoology*, after Sedgwick and Darwin.)

The Algerian reefs are divided into 10 regions, only one of which is dredged each year, 10 years being considered time enough to allow the beds to recuperate. They are dredged in waters from 25 to 1000 feet, though mostly in the shallower depths.

The value varies according to color, size and current demand, the last fluctuating greatly with the changes of fashion. The finest tints may bring \$400 to \$600 per ounce. Ordinary reds in small pieces, \$10 per ounce. Fine pieces called "collette," used for children's necklaces, etc., bring \$1 per ounce. Very large pieces are much in demand in China for the official buttons of the mandarins.

CHAPTER IV

ECHINODERMATA

This phylum consists of a number of well-known forms all of which are marine and most of which are very slow in their motions. As their name indicates they are the "spiny-skinned" animals, though the spininess varies greatly in different species. They are radially symmetrical and were, therefore, by earlier writers classed with the Cœlenterates as "Radiata." Their radiate structure is usually built on a plan of five, and their organs of locomotion, in most cases, consist of small sucker-like tube feet, controlled by a characteristic system of water tubes known as the water-vascular system. Unlike the cœlenterates they have a well-developed cœlom and possess the three cell layers characteristic of the higher animals. An anus, distinct from the mouth, is generally present.

There are many extinct groups of echinoderms that, as fossils, are interesting and important geologically.

The living representatives of this phylum are usually divided into five classes, three of which are of some, though not of very great, economic importance, the other two classes are of scientific interest only.

I. Asteroidea, Fig. 13. As their name indicates these are the starfishes, the most familiar of the echinoderms. They are typically five-rayed, the rays meeting in an indefinite central disk. On the upper or aboral side is a generally distinct madreporic plate, on the lower or oral side is seen the centrally located mouth, radiating from which are the five ambulacral grooves, filled with tube feet.

II. Echinoidea, Fig. 14, the sea urchins. The pentanerous arrangement is not so obvious here as in the preceding class since there are no radiating arms. The calcareous plates are united into a more or less globular shell or test, Fig. 15, covered with movable spines (hence the name, hedgehog), and perforated with five radiating sets of holes for exit of the long, slender tube feet. The plates that bear

the perforations form the ambulacral areas, the plates between these five areas form the interambulacral areas. The mouth is in the centre of a membranous peristome and is usually provided with a complicated jaw apparatus known as Aristotle's lantern.

III. **Holothuroidea**, Fig. 16, sea cucumbers. As the popular name indicates these animals, especially certain species, are distinctly

FIG. 13.—Starfish. $\times \frac{1}{2}$.

cucumber-like, having an elongated, spindle form, with the anus at one end and the mouth, surrounded by branching tentacles at the other. The bony skeleton here consists of small variously shaped plates, usually in such small quantity that the body wall has a soft leathery texture.

IV. **Ophiuroidea**, Fig. 17. These are the brittle-stars or serpent-stars; the first name is appropriate because of the brittle, delicate character of the rays; the latter name comes, as the class name indicates, from the snake-like character of the rays. The distinct central disk and snake-like arms are sufficient to identify the members of the class, Fig. 17. In some species the rays are much branched, making the

FIG. 14.—Sea-urchin. $\times \frac{3}{4}$.

animal very complex in appearance, as in the basket fish or Venus' basket.

V. **Crinoidea**, Fig. 18. These are the feather-stars, sea-lilies, or stone-lilies, named from their feather or plant-like appearance. They have five arms which often branch repeatedly and give the feathery appearance. They are generally attached by the aboral apex, either during their developmental stages or throughout life, sometimes by a

FIG. 15.—Test of sea-urchin, with spines removed. $\times 1$.

FIG. 16.—A sea-cucumber, *Thyone briareus*, partly buried in the mud. $\times \frac{1}{2}$.
(From Hegner, College Zoology, after Pearse.)

long flexible stem, made up of disk-like segments. They occur at all, though mostly moderate, depths; many are known only as fossils, their calcareous skeletons helping to form extensive limestone deposits.

The **Asteroidea** are of very considerable negative importance since they are a serious menace to the shellfish industry, especially to oysters. A single starfish, in captivity, is said to have eaten 20 clams in six days, and since along the northern coasts the starfish are often extremely abundant, they sometimes are very destructive to

FIG. 17.—Serpent or brittle-star. $\times 1$.

oyster beds. The method of getting rid of them will be discussed under the head of oyster culture.

The **Echinoidea**, under the name of *sea-eggs*, are of some, though not very great, economic importance. In the West Indies, Italy and in the far east they are largely eaten, both raw and cooked, especially when they are sexually mature and full of eggs, as it is the eggs that are eaten. A large sea-urchin just before spawning contains a very considerable quantity of roe. A decade or more ago at Barbados, the centre of the sea-egg industry, the annual business was worth about \$20,000.

The **Holothurians** are the most important, economically, of the

echinoderms. Several dozen species are used as food, especially by the Chinese, and other orientals, under the name *trepang*; they are also called *bêche-de-mer*. Some species bring very high prices, others seem less desirable.

The animals, some of which may reach a length of two feet, are eviscerated, the leathery walls are then boiled, soaked in fresh water, smoked, and dried. The result is an irregular mass of rubber-like substance which can be transported easily and is made into soup and other articles of diet, which are said to be very palatable.

FIG. 18.—A crinoid, *Pentacrinus maclearanus*. $\times 1$. Only a part of the stem shown. (From Hegner, *College Zoology*, after *Cambridge Natural History*, from Thompson.)

Trepang is prepared by the Chinese of California and Hawaii, but the chief centres are in the Orient; for example 600 tons annually are collected from the north coast of Australia, and the annual trade amounts to hundreds of thousands of dollars. Considerable quantities are also collected in the West Indies.

The **Ophiuroidea** have practically no economic importance and the same is true for the **Crinoidea** except for their aid in forming limestone beds and in enabling geologists to determine geological horizons.

CHAPTER V

PLATYHELMINTHES. FLAT-WORMS

In older texts the group name "Vermes" was used to include all of the worms. In modern books the worms are usually placed in three or more phyla—the Platyhelminthes or flat-worms, the Nematelminthes or round-worms, the Annulata or segmented-worms; and sometimes the curious little worm-like rotifers are placed in a phylum of their own, though they and some other worms are of uncertain affinities. The first three of these groups will be taken up in order, as each has considerable economic importance.

The *flat-worms*, though a lowly group, are more highly specialized than the coelenterates. They have three germ layers, the mesoderm forming important systems of organs—muscles, urogenital organs, etc. They are bilaterally instead of radially symmetrical and, as the name indicates, are of a distinctly flattened form. Their internal

FIG. 19.—*Planaria*. A common fresh-water flat-worm. $\times 5$.

structures are difficult to make out in the laboratory, and vary considerably in different species, being highly degenerate in some parasitic forms.

The flat-worms are usually divided into the three following classes:

I. **Turbellaria**, Fig. 19, free living forms with ciliated ectoderm; found in fresh and salt water, rarely on land. Represented by the familiar genus *Planaria* of our ponds and pools.

II. **Cestoda**, Fig. 20, long, much flattened forms divided into numerous (sometimes many hundred) more or less independent segments, no alimentary canal present; parasitic in habits. Represented by the common tapeworms.

III. **Trematoda**, Fig. 21, usually short and broadly flattened, with ventral suckers and much branched digestive and reproductive organs. Parasitic in habits. Represented by the liver and other flukes.

Since the *Turbellaria* have little if any economic importance they will not be further discussed.

The **Cestodes** or tapeworms, Fig. 20, are found in the digestive tracts of vertebrates. Naturally those found in man are of the most interest and importance. There are at least two large tapeworms parasitic in man: *Tænia saginata*, the unarmed, beef, or fat tapeworm, the commonest form, and *T. solium* or pork tapeworm. The former is taken into the body by eating imperfectly cooked beef; the latter by eating imperfectly cooked pork. The latter is the more dangerous but, according to Osler, is very rare in the U. S. The former is found practically everywhere and though unpleasant is not necessarily very serious.

The life-history of *T. saginata* is briefly as follows: the adult worm lives in the intestine of man; usually only one worm is found in an individual, but as many as 59 have been reported. The worm has a small head, about 2 mm. in diameter, Fig. 20, B, with four suckers but without the circle of hooks that is found in *T. solium* and that is shown in the figure. Following the head or scolex is a slender neck, the segments of which gradually enlarge toward the posterior end until, in the main body of the animal, they may be 1 cm. wide and 2 or 3 cm. long. There may be 1000 or more segments or proglottids in a large worm, totaling a length of 20 or 30 feet. Each of the posterior segments is a complete animal sexually, and they are constantly breaking off and passing to the exterior with the feces.

In ridding a patient of tapeworm by the use of purgatives it is necessary to cause the extrusion of the entire worm, for if the scolex remain attached to the intestine the segments will be rapidly regenerated, at the rate, perhaps, of a dozen a day, so that the worm will soon regain its normal size.

It is estimated that a single worm may produce 150,000,000 eggs per year; these, together with entire proglottids, are passed to the exterior and may be taken into the digestive tract of a beef with grass or in drinking water. While still in the proglottids the eggs are fertilized and develop into tiny embryos. These embryos if taken into the intestine of a beef burst out of their containing shells, burrow through the digestive walls of their second host and become encysted, as tiny bladder-shaped worms known as *cysticerci*, or bladder worms, in the muscles, especially in the tongue and chewing

muscles. If, now, this muscular tissue be eaten, imperfectly cooked, by man, the cysticerci, when the meat is digested complete their development into the adult *T. saginata* in the intestine of the new victim.

Tænia is most common in women especially between 20 to 40 years, and a worm may live for years, if not expelled by proper treatment. Of course, if no raw or very rare beef be eaten it is impossible to be infected; probably most infections come from privately killed cattle, as the larger slaughter houses keep the beef in cold

FIG. 20.—Human tapeworm, *Tænia solium*. A, the entire animal. $\times \frac{1}{4}$. B, the head or scolex, *sc*, enlarged; *n*, neck region; *p*, segment or proglottid; *s*, suckers; *sc*, scolex; *gp*, genital pore; *h*, hooks.

storage for three weeks, which is thought to destroy the cysticerci that may be present. Thorough salting will also kill the cysticerci.

The life-history of *T. solium*, which most books describe as the "common" tapeworm, is essentially the same as that of *T. saginata* except that the hog is the second host. The head here is very tiny, not so large as the head of a pin, and is armed with hooks, hence the name "armed" tape worm. The cysticercus of *T. solium* is not so easily killed by cold storage as that of *T. saginata*, so that there is always danger from eating raw pork, though the greatest danger is from another worm, to be described later.

T. solium is a more dangerous parasite from the possibility of the occurrence of cysticerci in man, forming vesicles known as *hydatids*, which may cause death. These hydatids are embryos that, in certain cases, develop in the intestine where they were born and then migrate into the muscles of the first host.

The **Trematodes**, Fig. 21, are represented by the liver, lung, intestinal and venal flukes of man and other animals, the disease being known, in a general way as *Distomiasis*, from *Distoma*, the generic name of the common flukes. According to Osler there are six species of liver flukes known in man. One of these is extremely common in some parts of the Orient and has occasionally been found in the United States. The patient may die after many years of illness. One of the commonest of the flukes is *Distomum hepaticum*, living in the bile ducts of sheep and other herbivorous animals. It is found the world over and sometimes causes severe loss among flocks from *liver rot*.

Since a single fluke is said to produce 500,000 eggs and since there may be 200 adult flukes in a single sheep, it would seem that the disease should be extremely common, but the life-history, as will be presently seen, is so complicated that the mortality is enormous and but few eggs ever produce adult flukes.

The life-history of the sheep fluke is, briefly, as follows: The fertilized egg is deposited by the hermaphroditic adult in the bile ducts of the sheep, whence it passes to the intestine and thence to the exterior with the excrement. If the ovum chance to get into water at the right temperature it develops into a ciliated larva known as a *miracidium*. In swimming about, if this larva come in contact, within a few hours, with a fresh water snail of a certain species it burrows into the soft tissue of the mollusc where, in about two weeks, it develops into the next stage, the sac-like *sporocyst*. The sporocyst gives rise to several *redia*, of which there may be one or more generations, the final generation becoming the tailed *cercaria*. The cercaria leaves the body of the snail and after swimming about for a time forms a cyst on a blade of grass. If this blade of grass be eaten by a sheep

FIG. 21.—Liver fluke, *Fasciola hepatica*. $\times 1$. g, genital pore; m, mouth; s, ventral suckers.

the larva escapes from the cyst, makes its way from the intestine into the bile ducts where it assumes the adult condition. It will be seen that the chances for an egg to meet all of these unusual conditions are very slight; hence the enormous number of eggs produced by each adult fluke.

CHAPTER VI

NEMATHELMINTHES. ROUND-WORMS

These are the round or thread-worms, which are characterized by their long, slender, cylindrical bodies that are entirely devoid of internal or external segmentation. Their internal structure is usually moderately simple, as might, perhaps, be expected of a group, many members of which are parasitic. Some of them are of microscopic size; others reach a length of a meter. Their chief if not only claim to economic importance lies in their parasitic habits.

FIG. 22.—Parts of *Ascaris lumbricoides*. *a*, *b*, and *c*, enlarged; *d*, highly magnified *a*, posterior end of a male with two penial setæ (*Sp*); *b*, anterior end from the dorsal side, showing the dorsal lip with its two papillæ; *c*, the same from the ventral side with the two lateral ventral lips and the excretory pore (*P*); *d*, egg with external membrane of small clear spherules. (From Hegner, College Zoology, after Sedgwick, from Leuckart.)

One of the larger and more common of the round-worms is the genus *Ascaris*, Figs. 22, 23 and 24, found as a parasite in the intestine of man, horses and pigs. It is a brownish worm, about 6 mm. in diameter and from 12 to 30 cm. long, the female being usually somewhat the larger; the main features of its anatomy are illustrated by the accompanying figures. The species common to man is *A. lumbricoides*, the human eel worm. It is one of the most common of the human worm parasites, being frequently found in children from 5 to 10 years of age, and in women more often than in men. It is also more common in warm than in cold climates, and is more frequently

met with in the country (where sewage disposal is often crude) than in cities. There are usually from one to half a dozen worms in one patient, but as many as 600 in one person have been reported. They may merely cause diarrhea and other discomforts or they may be fatal. The condition may be identified by finding the worms or their eggs in the patients' stools. The history is simple, no second host being necessary. The eggs that are passed out of the body in the feces may be taken into the digestive tract of the same or of another person in drinking water, upon unwashed fruits, vegetables or salads,

FIG. 23.—Transverse section of *Ascaris lumbricoides*. $\times 15$ cu, cuticle; dl, dorsal line, der. ephm, epidermis; ex.v, excretory tube; int, intestine; lat. l, lateral line; m, muscular layer; ovy, ovary; ut, uterus; v.v., ventral line. (From Hegner, College Zoology, after Parker and Haswell, from Vogt and Yung.)

or by simply eating with dirty hands; possibly the eggs may be carried to man's food or water by flies. It is thus easy to understand how young children may be infected and why women, who generally handle the raw fruits and vegetables, are more subject to the disease than men. Also how bad sewage may spread the eggs. After entrance into the body it takes from one to several months for the eggs to develop into the adult worms.

Santonin and calomel are the usual drugs used to rid the intestine of the eel worm.

Hookworm.—Probably the most widespread and important worm parasite of man is the now popularly known hookworm, of which there are two chief forms, the European, *Ankylostoma duodenale*, and the American, *Necator americanus*. The disease caused by this worm is generally known as hookworm disease, or technically as *uncinariasis* or *ankylostomiasis*.

The parasites occur in most parts of the world and practically all tropical countries show the presence of the disease, often in a large percentage of the population; for example 90 per cent. of the people of Porto Rico formerly were infected. While typical of the tropics, the disease is often common in the temperate zones. In the southern states of the Union the disease is very prevalent; especially among the poorer classes. The disease has been recognized in tropical countries for three centuries, though its cause was not discovered until past the middle of the nineteenth century. The first case in the United States was reported in Philadelphia in 1893.

Those who live, or have travelled in the southern states are familiar with the so-called "poor whites" of that region. It has been estimated that, at least until a few years ago, there were some 2,000,000 of these unfortunates. They were formerly considered to be a sort of degenerate race, too lazy or stupid or both to work, who eked out a miserable existence on their pitiful little plantations. These people are pale and anæmic and often thin to emaciation; the children are stunted physically and

FIG. 24.—A female *Ascaris lumbricoides* cut open to show internal structures. $\times \frac{3}{8}$. 1, pharynx; 2, intestine; 3, ovary; 4, uterus; 5, vagina; 6, genital pore; 7, excretory tube; 8, excretory pore. (From Hegner, College Zoology, after Shipley and MacBride.)

deficient mentally; many are tuberculous. One of the curious and disgusting characteristics of these people, at times, is the habit of eating dirt, wood, hair, clothing, etc., although the victim usually will deny the habit.

About the beginning of the present century Dr. C. W. Stiles, a zoologist, then in the Bureau of Animal Industry, now in the Marine Hospital Service, knowing the effect of hookworm upon the lower animals, made the prediction that it would be found that the condition of these supposedly lazy "poor whites" of the south was due to their being infected with hookworm. The newspapers made great sport of Dr. Stiles' "lazy germ" but the prediction was very soon fulfilled,

FIG. 25.—Hookworm, *Necator americanus*. A, male; B, female. $\times 10$. (After V. L. Kellogg and Doane, *Economic Zoology and Entomology*, from Wilder.)

and we now know that these "poor whites" are not degenerates but are sufferers from a serious, though usually easily cured, disease, named from the worm that is its cause.

The worm, Fig. 25, is a small nematode about 1 cm. in length and about the diameter and color of a very dirty piece of sewing cotton. The male may be easily distinguished from the female by the flaring, fin-like posterior extremity. At the anterior end is the tiny mouth, armed with sharp teeth for puncturing the soft mucosa of the digestive tract; it is in the jejunum that they are chiefly found. They vary in number, in a single individual, from about a dozen to over 4000; but the severity of the attack is not always in proportion to the number of worms found, death having resulted with the former number of worms and recovery with a latter number. They may live in the intestine for five or six years, or even longer. The complete

life cycle of the worm cannot take place in the single person, so that the number of worms in the intestine can be increased only by a new infection.

The female worm produces the eggs, which are about 35×70 *micra* ($\frac{1}{1000}$ mm.) in size, in enormous numbers and they pass to the exterior with the feces, as many as 4,000,000 it is estimated, with one stool. Desiccation, direct sunlight, too much water and, generally, freezing will kill these eggs, which have usually begun to segment when passed out with the stool.

The rapidity of development depends upon the temperature and moisture, but the larvæ become infective in four or five days; under favorable conditions these larvæ may live for months.

Infection may take place either by the mouth or, more commonly, through the skin. It is the entrance of the tiny larvæ through the skin, more often of the feet, but of any part of the body, that causes the irritation known as "ground itch," "foot itch," "dew itch," etc. A large percentage of hookworm disease histories show cases of ground itch. The mode of entry through the skin was discovered in 1898 by Looss in a very interesting way. While experimenting with hookworm larvæ he spilled some of them on his hand; he noticed a burning sensation and in a few minutes the larvæ had disappeared. After the proper interval, about two months, he found himself suffering with the hookworm disease. To determine what had become of the larvæ that were spilled on his hand he poured some larvæ on the leg that was about to be amputated from a boy; on sectioning the skin of this leg, after amputation, he found the larvæ had worked their way through the skin by way of the hair follicles, sweat ducts, etc. To follow the further course of the larvæ he placed some of them on the skin of a number of dogs which were killed and examined at various intervals. In this way he worked out the entire course of the larvæ from the skin to their final resting place in the intestine, which is as follows: after passing through the skin they enter the subcutaneous blood vessels and are carried by the blood current to the heart; thence to the lung capillaries, from which they burrow through the tissues into the lung alveoli, thence they work their way up the trachea to the œsophagus, down which they pass to the stomach and intestine. It is the tiny lesions made by the larvæ in passing through

the lung tissue that cause the patient to be unusually susceptible to tuberculosis.

The question will be asked—"How can a comparatively small number of tiny worms cause such a marked anæmia in a full grown human being?" The worms cause their serious effects in two or three ways. The amount of blood actually consumed by them is, perhaps not very serious, but it is supposed that they secrete a substance from glands in the head that prevent clotting of the blood, so that as they move from place to place in the intestine the tiny wounds they leave continue to bleed for some time. Again it is stated by some, that another substance is secreted by the worm that prevents the formation of new corpuscles to replace those that are lost. If both of these substances were at work at the same time the results might be most serious. Still another result of their work is seen in the numerous small sores or ulcers left in the mucosa of the intestine by the bites of the worms. These lesions give many possible points of bacterial infection.

One hopeful aspect of the disease is the usually easy cure, by the use of two cheap drugs, Thymol and Epsom Salts. They should not be taken without the advice of a physician, and should not be used along with alcohol nor any sort of oil, as the results might be very serious or even fatal.

It is, of course, chiefly through soil pollution that the disease is spread. Negroes in the south are almost all infected with hookworm, but for some reason, probably from having been infected through long generations in Africa, they are not seriously affected by the parasite and hence are not apt to subject themselves to treatment. As they are notoriously indifferent to sanitary laws, they probably are the chief instruments in the spread of the disease and are the greatest problem in its attempted control. The Rockefeller Hookworm Commission is endeavoring by a campaign of education and wholesale medical treatment to eradicate this curse of the south, which if accomplished will go far toward solving many of the economic problems of that region. What treatment and sanitation can accomplish is shown by the change in conditions in the great Bilibid prison in Manila, P. I. "When the Americans took charge of Bilibid prison the death rate was 238 per 1000 per year; by improving the sanitary conditions this death rate was reduced to about 75 per 1000; here it remained stationary until it was discovered that a very high percentage of the prisoners

were infected with hookworms and other intestinal parasites; then a systematic campaign was inaugurated to expel these worms, and when this was done the death rate fell to 13.5 per 1000."

Trichinella (Trichina) spiralis, Fig. 26, is a small nematode the adult male of which is about 1.5 mm. in length and a female $\frac{3}{4}$ mm. Both sexes are enlarged somewhat toward the posterior end, where, in the male, are two short, conical protuberances.

The adults are found in the intestine of man and other animals. The female worm produces a large number of embryos, perhaps 10,000 or more, which immediately begin to migrate into the surrounding tissues, finally finding their way, perhaps through the blood and lymph streams, to the muscles of their host where they grow until nearly 1 mm. in length. As it grows the embryo coils itself into a spiral,

FIG. 26.—*Trichinella spiralis* encysted among muscle fibres. Highly magnified. (From Hegner, College Zoology, after Shipley and MacBride, from Leuckart.)

and forms an elliptical cyst around itself as it lies in the connective tissue between the voluntary muscle fibres. It has been estimated that there were from 5,000,000 to 100,000,000, cysts in the bodies of persons who have died of the disease. This cyst, after seven or eight months, begins to degenerate and becomes calcified, and the worm is destroyed, though it may take from 2 to 10 years. The adults get into the human intestine from eating uncooked pork in which there are cysts. The cysts dissolve in our intestine, thus liberating the worms which in five or six days are able to produce embryos, and this they may continue to do for a month, if the adults are not gotten rid of by purgatives or by diarrhea; in any case the adult worms usually disappear in five or six weeks. Just how the hog becomes infected is uncertain, probably by eating infected offal, or infected rats; certainly the hog seldom has the opportunity of eating human flesh with or without the trichinella cysts.

If the disease, *Trichiniasis*, be recognized before the embryos have

begun to migrate it may be arrested by use of calomel and other purgatives, but after the worms are in the muscles there is no treatment that will affect them.

The death-rate has varied in different outbreaks from 1 to 30 per cent. In America the disease is comparatively rare and is largely confined to foreign-born people who make a practice of eating raw ham, sausage, etc. In certain German States where this practice is very common the disease is proportionately more prevalent. As a sure preventive it is simply necessary to thoroughly cook all pork. It is said that the centre of a large piece of fairly well cooked pork may contain live cysts and that salting does not always kill them. Pork from private slaughter houses is more apt to be infected. The fact that pork is marked "U. S. Inspected" does not guarantee it to be free from trichinella.

Filaria is a genus of small (less than 1 mm.) round-worms causing, in man, various diseases. One curious fact about certain species is that they are found in the human blood at night but not during the day, or at least in very much smaller numbers. In a case where a patient reversed his habits and slept during the day the parasites also reversed their habits and were found during the day. How the parasites enter the blood is not certain, probably by the bite of a mosquito, possibly through drinking water. It is often very common in the tropics. One of the diseases probably due, at least in some cases, to this parasite is *elephantiasis*, which causes enormous and incurable enlargements of the limbs and other parts of the body. There seems to be no drug that will destroy this parasite in the blood.

Guinea-worm (*Dracunculus*) is one of the largest of the round-worms, reaching a length of nearly a meter. The larvæ live in a water flea, Cyclops, and probably gain access to the human digestive tract in drinking water. Here they mature and the male dies and is voided. The female, after being impregnated, leaves the intestine and becomes fully developed in the subcutaneous tissue. She contains large numbers of embryos and to get these to the exterior she migrates downward into the leg, usually reaching the foot, where the head punctures the skin, forming a small vesicle which ruptures and allows the embryos to escape. The worm may then leave the body spontaneously or it may be carefully withdrawn, care being taken not to rupture it. It is sometimes the custom to wind the extruded end on a small stick

to prevent the worm from withdrawing into the body, each day a little more of the worm is wound on the stick until it is all out of the skin. It may also be removed by surgery or may be killed by injections of bichloride of mercury.

Pinworm, *whipworm* and various other small nematodes are sometimes parasitic in the human digestive tract.

CHAPTER VII

ANNULATA, SEGMENTED WORMS

The Annulata or Annelids are those worms in which the elongated, usually more or less cylindrical, body is externally divided into a number of rings representing the internal division into a series of more or less similar somites or metameres. There is usually an extensive coelom and a complicated system of blood vessels. The nervous system usually consists of a dorsally located brain or cerebral ganglion in the anterior region, connected around the digestive tract to a ventral nerve cord which usually has a series of ganglia corresponding to the somites. The excretory organs are paired nephridia, which are coiled tubes, usually one pair for each somite, connecting the coelom with the exterior.

The annelids are variously classified by different authors; the two most important classes and the only two of serious economic importance are the **Chætopoda**, represented by the earthworms and the **Hirudinea** or leeches.

Earthworms.—There are some 800 species of earthworms, about 90 of which are found in North America. There are about a dozen species of the common *Lumbricus* and *Allolobophora*. There are several from South Africa and Australia that are described as being $1\frac{1}{2}$ meters in length. They are found everywhere except in frozen latitudes and altitudes and in dry sandy regions. They generally burrow below frost in winter though some are said to survive freezing. According to the operator of a large steam-shovel they are sometimes found 18 or 20 feet below the surface of the ground.

They feed on almost any kind of organic matter, a considerable portion of which they obtain from earth that is passed through the body. This earth from which the food has been extracted is deposited at night around the openings of their burrows as fine pellets known as castings. The amount brought up each night by each worm is so considerable as to

interfere with the course of the golf balls on the putting greens of golf courses. To rid these greens of this annoyance they are sometimes sprinkled with a lime-and-sulphur mixture or some other poison that is harmless to grass. As soon as the liquid soaks into the ground the worms begin to wriggle out of their unseen burrows so that they may be picked up and destroyed. To illustrate the abundance of earthworms in the soil, the writer once collected, in this way, over one hundred worms, big and little, from a square yard of green. This habit of bringing the subsoil to the surface is most important to the growth of vegetation, the burrows make the soil porous, thus allowing air and moisture to penetrate the earth and making it easier for roots to work through the soil, and the castings are constantly building up a finely divided surface at the rate, according to Darwin, of about one-fifth of an inch each year, so that in a generation a rocky field may have all of its stones buried out of sight. The intestinal secretions mixed with these castings are probably beneficial to the soil.

FIG. 27.—Medicinal leech, *Hirudo medicinalis*. $\times \frac{3}{4}$. The larger sucker is at the posterior end.

Darwin remarks upon the fact that long before the plow was invented, even in the form of a crooked stick, the earthworms were continually turning up the soil in this way. Although they may sometimes do some damage to young and tender plants, earthworms are evidently of immense benefit to man. Certain laboratory experiments, also, have shown them to be of undoubted benefit to plants.

It is also said that earthworms may be and actually are used as food, though they will probably never be popular among civilized peoples. On the other hand they may occasionally be a source of infection in certain diseases by burrowing in the carcasses of buried animals and bringing the germs to the surface where they may infect other animals. They are thought to convey the germs of gapes, a disease of chicks caused by a small worm parasite.

FIG. 27a.—Diagram of the internal organs of the leech. 1, head with eye-spots; 2, muscular pharynx; 3, 1st diverticulum of crop; 4, 11th diverticulum of crop; 5, stomach; 6, rectum; 7, anus; 8, cerebral ganglia; 9, ventral nerve cord; 10, nephridium; 11, lateral blood vessel; 12, testis; 13, vas deferens; 14, prostate gland; 15, penis; 16, ovary; 17, uterus. (From Hegner, *College Zoology*, after Shipley and MacBride.)

Leeches, Fig. 27.—The leeches, of which the genus *Hirudo* may be taken as an example, are somewhat flattened annelids, with a large posterior and a smaller anterior sucker; the mouth is in the centre of the latter and may or may not be armed with jaws or teeth. Only the digestive system will be noted here. It consists of a short pharynx into which open certain glands whose secretion is to keep the blood, on which the animal feeds, from clotting. The pharynx, Fig. 27a, 2, opens into an enormous crop, 3, 4, with about 11 pairs of lateral pouches for the storage of enough blood to last, perhaps, for many months, as the leech may have very infrequent opportunities for feeding. Back of the crop are a small stomach, 5, and intestine, 6, opening to the exterior through a dorsally located anus, 7. The leech is admirably adapted to its peculiar parasitic mode of life. Its suckers enable it to quickly attach itself to a passing animal, mammal, turtle, fish, etc., its mouth enables it to extract blood from its host without pain to the host, its glands keep the blood from clotting, and its huge crop enables it to store up a very large quantity of blood at each of its probably infrequent feeding times.

This power of extracting a considerable quantity of blood, in a painless manner, has given the medicinal leech, *Hirudo medicinalis*, its value to man. In the case of bruises and certain other pathologic conditions it is merely necessary to apply a hungry leech—they may be 12 to 15 cm. long—to the desired spot and it will painlessly gorge itself with blood and then drop

off. So common was leeching in olden times that doctors were often called "leeches." Although not so commonly used in medicine at the present time leeches are used in some cases to remove small quantities of blood from a tender or sensitive region. It is also said that leeches may be used for food, but, like earthworms, they are not likely to become popular articles of diet. The other representatives of the Annulata, though of great scientific interest and importance, have practically no economic importance except as scientific specimens.

CHAPTER VIII

MOLLUSCA

The mollusca are soft bodied (*mollis*, soft) animals, usually with an external shell or an internal “pen” or bone, found both on land and in fresh and salt water. They are primitively bilaterally symmetrical, but this symmetry is often obscured in the adults. They are unsegmented. Although the various classes seem at first glance, very dissimilar, yet they have certain structures in common and they have a similar mode of development. Two characteristic organs of the

FIG. 28.—Fresh-water mussel, *Anodon*. $\times \frac{3}{4}$. *f*, foot, protruded; *g*, line of growth, only a few of which have been drawn; *ds*, dorsal siphon; *lg*, hinge ligament; *u*, umbo.

phylum are the foot, variously modified for different uses, and the mantle, inclosing between it and the main body the mantle cavity into which the digestive and urogenital organs open. The characters, mainly of the foot, mantle, shell, gills and nervous system, determine the classification of the phylum, which is one of great economic importance.

Five classes are usually described.

1. **Lamellibranchiata** or **Pelecypoda**, Fig. 28. The bivalves, such as oysters, clams, mussels, etc. Usually bilaterally symmetrical.

the shell consisting of two more or less similar valves and the mantle of symmetrical lobes.

2. **Gastropoda**, Fig. 43.—These molluscs have usually a single, spirally coiled shell, and are not bilaterally symmetrical. They are the snails, slugs, etc.

3. **Cephalopoda**, Figs. 46 and 46a. Bilaterally symmetrical animals with the foot divided into arms which are provided with sucking disks. Well-developed nervous system concentrated in the head. Usually with a spiral external shell or with an elongated internal bone or pen. Ink sac usually present. The squids, cuttlefishes, octopi, and nautili.

4. **Amphineura**, Fig. 47. Bilaterally symmetrical forms often covered with eight transverse calcareous plates. Typically represented by the chitons.

5. **Scaphopoda**, Fig. 48. A small group of small marine forms whose tubular mantle secretes a slightly curved, conical shell open at both ends. From the shape of the white shell they are called the elephants' tusk shells or tooth shells.

Shell-fish have been used as food by man from prehistoric times. At various places along the sea-coast huge shell mounds or "kitchen-middens" are found as relics of the shell-fish devoured by past generations, the antiquity of which is indicated by the primitive implements sometimes found in these mounds.

The Oyster.—Of all molluscs, certainly of those found in America, the oyster, *Ostrea virginiana* (*virginica*), is the most important economically. A generation or more ago there were dredged in Chesapeake Bay, one of the most famous regions for the production of this bivalve, each year, about 17,000,000 bushels of oysters. These oysters, which were the "wild crop" obtained without cultivation, were shipped alive and in cans all over the country. The supply was considered to be "inexhaustible." Other extensive beds are found in Long Island Sound, in Louisiana, at other places on both coasts, in Japan, and in various European countries.

After this maximum dredging of the wild crop had continued for some years it began to be noticed that the supposedly inexhaustible supply was failing and, in 1882, Dr. W. K. Brooks, of Johns Hopkins University, was appointed by the Governor of Maryland, a commissioner to investigate the oyster business and to make recommendations for its improvement. The results of these and his previous investiga-

FIG. 29.—An oyster in the right valve of the shell, dissected so as to show the internal organs. The anterior end of the body is at the top of the figure, and the dorsal surface on the right hand. $\times 1$. *b*, the mantle; *c*, the muscle; *d*, the heart; *g*, the gill; *h*, the lips; *i*, the intestine; *j*, the liver; *m*, the mouth; *s*, the stomach. (From Brooks, *The Oyster*.)

tions were published by Brooks in his book, "The Oyster," in which he described in a popular yet scientific way, the natural history of the American oyster, and showed the necessity of conserving the supply by proper cultivation just as is done with most other natural food products. The food of the oyster consists of microscopic organisms living in the salt or brackish water in which the oyster thrives best. They are carried into the mantle chamber, Fig. 29, by the cilia covering the organs of that region and enter the mouth of the animal. Among these organisms, of course, may be disease germs, if the water be polluted with sewage, as will be noted below. It requires three or four years, depending on the food supply, etc., for the oyster to reach maturity.

In the European oyster the eggs are fertilized and begin their development in the gill tubes of the female, while in the American form it was found by Brooks that the eggs are fertilized outside of the female, in the surrounding water. Since an average Maryland oyster will lay the incredible number of 16,000,000 eggs per year, it is evident that the struggle for existence must be terrific or the sea would soon be filled with oysters. If the egg should happen to be fertilized, it segments and develops into a tiny ciliated larva which swims to the surface, where it may be killed by a heavy rain. After living for a time at the surface, if it escape its many perils, it sinks to the bottom, loses its cilia, develops a tiny shell, and attaches itself to some solid object, if such be found, and is known as a "spat;" if no solid object be present the young oyster will perish, but if it succeed in becoming "set" it will proceed to develop into the mature oyster.

Oyster Culture.—Brooks found that by mixing eggs and sperm from "ripe" oysters in salt water the eggs could be easily fertilized in unlimited numbers; but, for some reason, these artificially fertilized eggs when they develop to the spat stage will not set, so that this stage of oyster culture is not practicable. What may be done is to allow the spat to form in the natural way and then collect it by placing various kinds of hard objects in the water at the breeding season; if placed in the water too long before the spat are ready to set these solid objects, known collectively as "cultch," may become covered with mud or other sediment and thus prevent the spat from setting. Various substances are used as cultch: tiles; a bunch of twigs (bamboo in Japan) tied together and sunk to the bottom with a stone; crushed rock; scrap

tin from can factories; scallop shells; and especially oyster shells. New beds may be started by spreading the cultch over the bottom at the breeding season and then distributing "wild" oysters, that are about to spawn, over the cultch. After the spat has "set" over the cultch and has grown into "seed" oysters of an average size of half a dollar, the cultch may be collected, broken up and spread over the bottom again to prevent the growing oysters from crowding each other, Figs. 29

FIG. 30.—A bed of well-shaped, marketable oysters. $\times \frac{1}{10}$. (Photograph by Grave, from Brooks, *The Oyster*.)

and 30. This is the general method of oyster culture as carried on in many places. Of course, it necessitates a survey of all the oyster grounds, just as farms are laid out, in order that dishonest dredgers, of which there are many, may not reap where others have sown. It is also obviously more troublesome than harvesting the "wild" crop, but unless some sort of culture be adopted the wild crop will inevitably become exhausted. The most serious difficulty in such cases always

FIG. 31.—Upper figure, an oyster shell to which about 150 young oysters have attached themselves. Lower figure, a pipe from Chesapeake Bay upon which six oysters have grown. (*From Brooks, The Oyster.*)

is to get the proper legislation enacted by ignorant or dishonest legislatures.

There are various difficulties with which the oyster farmer has to contend. If the water be too cold the oysters may grow but not reproduce; if it be too shallow it may freeze in exceptionally cold weather; the salinity of the water may not be right.

Although there are no known epidemic diseases of oysters, there are several enemies that cause trouble; the worst of these is the starfish,

as has been noted in connection with the Echinodermata; while not found in the southern beds it is so numerous and destructive farther north as to make oyster culture impossible without active warfare against this enemy. They multiply very rapidly, where conditions are favorable. The best means of destroying them is to catch them on a "tangle," Fig. 32, of frayed rope and then kill them by plunging them into a tank of hot water. If cut to pieces and thrown back into the water the menace is increased, as many of the pieces will grow into complete starfish and thereby increase the total number of the pests.

FIG. 32.—A "tangle" of frayed rope or cotton waste used to collect starfish from oyster beds. (After J. L. Kellogg, *Shellfish Industries*, from U. S. Fish Commission.)

There are several snails, known as "drills" that are often quite destructive by boring through the shells, especially of young oysters. There are several fish such as the drum, sheepshead, skate, etc., that are injurious; and the oysters are sometimes smothered by mussels, sponges, sea-weeds and drifting sands.

Oysters are collected with tongs or by dredging. The former, Fig. 33, might be compared to a pair of heavy iron rakes with very long handles that are joined, scissors-wise, near the rakes. The tonger may stand in the stern of a row-boat or at the side of a larger boat and by a scissors motion scrape off the oysters from the bottom until

his tongs are full and then lift them up and empty them in the boat. The size of the tongs varies, the shortest handles being about 12 feet. They are used by the poorer oyster men, often in water too shallow for larger dredging boats. While 10 to 15 feet is the usual depth, they may be used in water as much as 30 feet deep. Needless to say tonging is very hard and, in cold weather, very exposing work.

The more modern and much more rapid method of collecting oysters is by means of the dredge, an iron frame with a heavy net behind to hold the oysters that the frame detaches from the bottom. The dredge

FIG. 33.—Oyster tongs. Laboratory employees tonging and culling oysters in Louisiana. (After J. L. Kellogg, *Shellfish Industries*.)

is used on larger sailing or steam vessels and may be hauled, by steam power, Fig. 34, from any depth at which the oysters are found. "Oysters that grow on trees" are a curiosity of the tropics, they are simply oysters that become attached to the submerged roots of aquatic trees (*i.e.*, mangrove). The small *mangrove oysters* of the West Indies are collected and sold in considerable numbers.

As noted above the oyster in feeding will take into itself any disease germs that may be in the surrounding water. The germs that enter the digestive tract are doubtless soon destroyed, but where present in

the water they will adhere to the gills and other organs of the oyster and may, if the oyster be eaten raw, thus enter the human system.

Although denied by some, there have been numerous cases of typhoid fever and other diseases that have been traced to contaminated oysters. It is claimed by some oystermen that during the cold weather, when oysters are most in demand, they are, in a sense, hibernating and take no food so that they cannot be seriously contaminated with disease germs. Whether or not, this be true it is obviously important to see that no oysters be sold that are taken from beds that are contaminated by

FIG. 34.—A steam power oyster dredge. (After J. L. Kellogg, *Shellfish Industries*, from a Report of the N. Y. Forest, Fish and Game Commission.)

sewage; most, if not all, of the States possessing oyster grounds now have laws that are supposed to prevent this danger. In some cases oysters from contaminated beds may be made safe by transplanting them for a certain length of time to pure water, until they are free from pathogenic organisms.

There are federal laws that regulate the interstate shipment of oysters except in sanitary ways, either in the shell or in sealed tin or glass vessels, surrounded by ice. A bivalve that has opened its

shell is not fit for food but it cannot contaminate those that are still closed.

The custom of "floating" oysters has been considerably discussed. By a "floated" oyster is meant one that has been brought into water of less salinity than that in which it grew, until it has absorbed this fresh water and thereby become swollen or bloated. This custom, when the fresh water is contaminated by sewage, as it often is near cities,

FIG. 35.—Long-neck clam, *Mya*, with byssus, *b*, attached to sand grains, *sg*. (After J. L. Kellogg, *Shellfish Industries*.)

was a serious source of contamination and was justly condemned; but if the water be pure the floating merely makes the oysters bulkier (by as much as 20 per cent., at times), and thereby diminishes their food value, when bought by the quart or gallon. For this reason the pure food laws require "floated" oysters to be so labeled. The floating also diminishes the salty taste of the oysters, which makes them more agreeable to some palates.

Soft or long neck clam, Mya arenaria, Fig. 35. This is the clam of New England, famous in clam chowders and clam bakes. It is

essentially a northern form where it was formerly found in enormous numbers. It spends most of its time buried in the sand or mud, sometimes to a depth of a foot. Its long siphons (neck) reach to the surface of the sand and are withdrawn when the sand is left bare by the retreating tide, leaving the characteristic hole that reveals the presence of the hidden clam, Fig. 36. The clams are obtained by digging them a low tide with a sort of short-handled, long-tined rake, shown in Fig. 36. The number of clams obtained under favorable conditions from a given area is sometimes astonishing, Fig. 37. The shells being thin (soft), they are often broken in digging them out of the sand.

FIG. 36.—Beach showing very numerous holes of long-neck clams. Clam rake in foreground. (After J. L. Kellogg, *Shellfish Industries*, from Report of Mass. Fish and Game Commission by Belding.)

Clam Culture.—Although the conditions suitable for the culture of soft clams are quite different from those noted above for oysters, they are not unusual and are fairly well understood; it is estimated that 400 bushels per acre, at a profit of 75 cents per bushel, could be raised. The chief difficulty in the way of successful clam culture is that the laws of some States make the clam bottoms public lands, so that the man who cultivates clams has no legal right to protect his plantings against trespass and theft. This clam has been transplanted to the Pacific coast where it apparently thrives and may become an important source of food for that region.

Hard or little neck clam, quahog, Venus mercenaria, Fig. 38. This clam is common along the entire Atlantic coast, but for some rea-

son is seldom eaten in the south where it is most abundant. The massiveness of its valves has given the name "hard," the shortness of its siphons the name "little neck," and the name "quahog" or "quahang," is said to be derived from an Indian name meaning "tightly closed." The smaller specimens, which may bring \$4 a bushel, are served in restaurants as "little necks," to be eaten raw from the half shell. Though sometimes found between tides, the

FIG. 37.—Long-neck clams dug from beneath one square foot of a flat. Such a yield is unusual. The ruler is six inches long. (After J. L. Kellogg, *Shellfish Industries*, from Report of Mass. Game and Fish Commission by J. R. Stevenson.)

quahog usually occurs in greater numbers in deeper water and is collected from such beds with a large rake with long, steel teeth and a handle as much as 60 feet long, so that their collection is very laborious. The clam has few enemies in its natural habitat and is so very hardy that it may be transported almost any distance, even in warm weather. Like the oyster, many of the northern quahog beds were dredged

till depleted, so that the canneries were compelled to move south to new beds.

The only effort, apparently, to conserve the supply that has been made has been to declare an occasional closed season. Enough experimental work has been done to indicate that culture of this clam might be carried on at a good profit.

Scallop, *Pecten irradians* and *P. tenuicostatus*, Fig. 39. These two species are found along the Atlantic coast, the former in more shallow waters, from Cape Cod to Texas, the latter in deeper waters, north of Cape Cod. The southern form seldom exceeds 3 inches in diameter and is the more common of the two, the northern species may reach a diameter of 7 inches.

FIG. 38.—Hard-shell clam or quahog, *Venus mercenaria*. $\times \frac{1}{2}$.

FIG. 39.—Scallop shell, *Pecten irradians*. $\times \frac{1}{2}$.

The only part that is usually eaten is the small, cylindrical adductor muscle, though the rest is perfectly good food. These meats are freshened by soaking them in fresh water; this process swells them greatly and of course increases the value of animals sold by bulk, though it makes them spoil much more quickly.

Pecten does not lie buried as do the preceding two forms, but moves about more or less actively by opening and shutting its shell, so that it is dredged by means of a "pusher," a rectangular iron frame with a bag at the back.

Owing to their perishability and the limited supply scallops are not used to any great extent at a distance from the coast. As the price is sometimes as high as \$5 a gallon, wholesale, they may be consid-

ered a luxury. What might be expected from scallop culture it is difficult to say.

Sea mussel, salt water mussel, Mytilus edulis, Fig. 40. The sea mussels have for ages been an important article of diet in Europe, but, for some reason, they have never become popular in America, though the natural beds would supply large quantities at a low cost, and by proper cultivation they might rival the oyster in importance; Field (82) summarizes his investigations upon the sea mussels as follows:

"1. The sea mussel, *Mytilus edulis* Linnæus, is not utilized as a food to any extent in the United States outside of the vicinity of New York City.

"2. As a food material it is superior to many articles which are commonly eaten. Scores of persons have pronounced it to be equal in flavor,

FIG. 40.—Edible salt water mussel, *Mytilus edulis*. $\times \frac{3}{4}$.

or even superior, to the oyster; it is easily digested, has a high nutritive value, and is exceedingly abundant and general in its range.

"3. Along most of our eastern coast the mussel is in season for food when the oyster is out of season.

"4. The mussel is well adapted to preservation. When canned or pickled it will retain its natural flavor for months.

"5. The mussel breeds at a prolific rate, it develops rapidly, requires less special conditions for growth than the oyster, and may therefore be easily cultivated.

"6. The only difficulty in the marketing of mussels for food purposes is that they spoil quickly after being removed from the water. It is necessary to use them within 24 hours after they are collected or ptomaine poisoning may result. To insure one's self against illness from eating them, the mussels must be taken from water that is pure and subject to the constant circulation of tidal currents.

"7. Other important ways for utilizing mussels are as bait for the fisheries and as fertilizer for the soil on which onions and carrots are to be raised . . ."

Edible Snails.—There are various species of snails that are used for food, most of them belonging to the common genus *Helix*; they are, of course, Gastropods. The eating of snails was known in Italy before the Christian era; the custom was introduced into France in the latter part of the eighteenth century which country is now the chief consumer of this mollusc. It is estimated that in Paris alone 200,000,000 snails are consumed in a season, September to April—the price varying from 50 cents to \$2 depending on the species, quality, etc. They are a delicacy, not a staple article of food, like beef.

Snail farms or "snaileries" are common in southern France, in Italy, and in Spain, though the business is not so profitable as formerly. The

FIG. 41.—Shell of Abalone, *Haliotis* sp. $\times \frac{1}{4}$.

snails are collected in the woods by peasants; they are put in "pens" or "gardens" surrounded by a low fence of wire netting, about 10,000 snails in a pen 25–30 feet square. They are fed on all kinds of vegetables or on bran-mash. Each snail lays about 50 to 60 eggs in the summer, which hatch and become sexually mature the next summer, but do not reach their full size until the second summer.

They are cooked in various ways: *i.e.*, they may be boiled, picked out of the shells, minced, flavored and then stuffed into the shells again. They could probably be easily raised in the United States in places that are useless for other purposes, but a popular taste would have to be created or they would have no market.

Abalone, genus *Haliotis*, Fig. 41. This familiar gastropod of the western coast is useful both for food and in the manufacture of orna-

ments from its shell. In some species the shell when polished is wonderfully fine mother-of-pearl, with all sorts of brilliant colors.

Window-glass shell, Placuna placenta, Fig. 42. This curious bivalve has shells so thin and flat that they may be cut into squares of 3 or 4 inches and set in window sash for lighting houses. Their pearly translucency is very pleasing, and they are very widely used in some parts of the tropics, for residences, churches and other buildings.

"The demand for window shell in other countries for the manufacture of lantern shades, screens, etc., in addition to the local use for windows, has so increased that there is danger of exceeding the supply. In the early part of the year the Bureau of Science undertook the planting of a new bed of these shells. Five thousand live shells were taken in Kawit

FIG. 42.—Window shell, *Placuna* sp., and square cut from a shell. $\times \frac{1}{2}$.

and planted on the mud bottom of the esteros and oyster beds at Malabon. I believe these will thrive, if they are not removed by the local fishermen." From report of Director Alvin Cox, Phila. Bu. Sc.

Camio or *helmet shells*, genus *Cassis*. These Gastropod shells owe their value to the fact that they are composed of different colored layers—white and black for example—so that a figure may be carved out of one color with the other color as a background. The carving of cameos, so important in Italy, has, it is said, degenerated from an art to a trade, so that the fashion has greatly declined.

Giant clams, genus *Tridacna*. These are the largest of the lamelli-branches and may reach a weight of 500 pounds. They are found in the oriental tropics and are said to sometimes drown pearl divers who happen to be caught between their mammoth valves. The valves

which may be a beautiful pure white color within are often used as fonts for holding holy-water in churches.

In parts of Africa and India *cowries* or *porcelain shells* are used as money and the well-known *wampum* of the American Indians was made from the shells of the quahog, especially those that were lined with blue, and from the colored adductor muscle scars of other lamellibranchs.

FIG. 43.—A gastropod shell, *Murex* sp. $\times \frac{3}{4}$.

Pearls and Mother-of-pearl.—The shells of lamellibranchs are secreted by the mantle. In most species this secretion is mainly a dull white calcium carbonate, but in some species it is laid down in glossy iridescent layers and is known as mother-of-pearl. If of a fine quality, it may be used for various ornamental purposes; if of a less fine grade it may still be used in the manufacture of pearl buttons. The pearls, which may be attached to the inside of the shell or may be free between the shell and the mantle, are formed by the same glands of the

mantle around some small foreign body as a nucleus. This foreign body may be a grain of sand, a dead egg, a dead parasite, or a small shot or other object introduced by man between the shell and the mantle. The irritation of this foreign body probably causes an active secretion by the mantle glands of the nacreous material in concentric layers over the offending object, the result being a pearl, whose value depends upon its size, shape, color, etc. If the pearl be attached to the shell it will, of course, have to be cut free, which will leave a scar on one side and render it fit only for a setting where this side will be hidden. In some places, it is said, fine shot are introduced between the mantle and shell to act as nuclei for pearls; the oyster is then replaced in the water to be examined for pearls at a later date.

This characteristic of the mantle has been made use of in producing the sacred clam shells that the Chinese Buddhists believe to have a miraculous origin, and that are sometimes seen in collections. Brooks (79) says:

“The inside of the shell has a beautiful pearl lustre, and along it is a row of little fat images of Buddha, squatting with his legs crossed under him, and his elbows on his knees. They are formed of pearl precisely like that which lines the rest of the shell, a little raised above its surface and outlined in faint relief, but they are a part of the shell, with no break or joint. In the process of manufacturing them, the shell of the living animal is wedged open, and thin images, punched out of a sheet of bell-metal, are inserted. The animal is then returned to the water, and is left there until enough new shell has been formed to cover them with a varnish of pearl thick enough to fasten them, and to hide the metal, while permitting the raised outline to be seen.”

Although pearls of considerable size are often found in the edible oysters and other bivalves they have little value, as the glands of the mantle do not secrete the proper nacreous material.

The precious pearls are found chiefly in the pearl oysters of the family *Aviculidæ* and in the pearl-bearing mussels of the family *Unionidæ*. The true pearl oysters are found in the Indian Ocean, Red Sea, Gulf of California and elsewhere, though the value of the pearls and mother-of-pearl varies greatly in different localities. In some places the shells are heavy and of fine quality and may be worth 50 cents each; in other places they are thrown away and only the pearls are sought.

The oldest pearl fisheries are on the north coast of the island of Ceylon, where pearls have been collected since the beginning of the Christian era.

Since the British occupation the fisheries have been under government control and have been a great source of revenue.

At certain intervals the government will advertise an open season for pearl diving and the natives flock to the fishing grounds by the thousands. At a given signal, each day the boats set out, and at the end of the day a second signal recalls them to shore. Small boats are used, each with 10 divers, in two gangs, an equal number of helpers, and two or three sailors. The diver descends to the bottom, 30 to 50 feet, with the aid of a heavy stone, works for 30-90 seconds and is drawn up with his basket of oysters. At the end of the day the oysters are taken to shore and placed in bins to decay. When thoroughly decayed they are carefully washed and examined for pearls; the stench may be imagined. The government claims a certain proportion of the shells and the divers take the rest. It makes an interesting form of gamble, as a collection of shells may have \$10,000 worth of pearls or it may contain none. For miles the shore is covered several feet deep with shells.

In America the most important pearl fisheries are in the Gulf of California, centering about La Paz. These fisheries were operated by Indians in the time of Cortez and were exploited by the Spanish government. The season here is from June to December. The expert Indian and Mexican divers, who were said to work on an empty stomach to increase the lung capacity, have been largely replaced by the present operators, chiefly San Francisco firms. Each boat now has a diving outfit, with one diver and a proper number of pump men and other helpers. About 300 oysters per day are collected by such a boat.

There are also fisheries on the coasts of Panama, Guatamala, Red Sea, South Sea Islands, Australia, the Sulu Islands, and elsewhere. In the latter two regions the shells are particularly fine and are collected for mother-of-pearl. At the town of Jolo, capital of the Sulu group the writer was asked one peso (50 cents) for a single valve of a large pearl oyster.

Some of the fresh-water mussels (Unionidæ), Fig. 28, of Asia, Europe and America are valuable both for pearls and for use in making pearl buttons. On account of their unusual color the pearls are often

very valuable, but in America they have never been very systematically sought, being mainly collected by farmers and others in a very wasteful manner. In Europe the supply has been conserved by carefully opening the shells with specially devised tools and returning the animals to the water after examination.

In America the Unionidæ are chiefly used for buttons and along the Ohio and Mississippi Rivers they have been so extensively dredged that they are threatened with extermination. The shells are drilled with tube-shaped drills that cut out disks of pearl from about 5 mm. to 30 mm. or more in diameter, Fig. 44; from these rough disks the pearl but-

FIG. 44.—Ohio River pearl mussel, *Uniono* sp., from which 15 button discs have been cut. Above are 3 discs of different sizes. $\times \frac{1}{2}$.

tons are made. Several dozen disks may be drilled from one shell, the number varying, of course, with the size of the disks and the size of the shell.

In both the pearl-bearing oysters and pearl-bearing mussels pearls are most likely to be found in distorted and abnormal specimens.

Ship-worms.—Of the few molluscs that are of negative economic importance probably the most injurious are the ship-worms, *Teredo navalis* and other species. In the days when all vessels were made of wood and were unprotected with metal sheathing these boring bivalves must have been, indeed, the “terror of ships.” Though they belong to the class of Lamellibranchs they are elongated, worm-like animals, and hence have been called ship-worms. They may reach a length of

4 feet and a diameter of 1 inch, Fig. 45. Sigerfoos (52) estimates that a single large female may lay 100,000,000 eggs. These eggs rapidly develop into free-swimming larvæ, typical of the lamelli-branchs. After further development these larvæ attach themselves

FIG. 45.—A ship-worm, *Teredo navalis*, in a piece of timber. $\times 1$. *p*, pallets; *SS*, siphons; *T*, tube; *V*, valves of shell. (From Hegner, *College Zoology*, after *Cambridge Natural History from Möbius*.)

to some submerged piece of wood and begin to burrow into it, gradually changing to the worm-like form as they do so. The newly attached larvæ are tiny animals, about 0.25 mm. long; on entering the wood they grow rapidly so that in about five weeks, in some species, they

FIG. 46.—Devil-fish, *Octopus* sp. $\times \frac{1}{4}$.

may be 100 mm. long. Sigerfoos estimated that a four-foot specimen was only about a year old. The rate of growth seems to be independent of the kind of wood, whether it be soft white pine or hard oak; probably the food supply is the determining factor. In a four-foot worm the

valves are an inch or less in length and are the means by which the worm bores its way into the wood. The rest of the soft body is uncovered so that the animal secretes a thin, smooth calcareous lining to its

FIG. 46a.—Squid, *Loligo pealii*. $\times \frac{1}{2}$.

burrow to protect itself from the rough edges of the wood. If the larvæ settle at the end of a log they burrow straight ahead in the direction of the grain of the wood, but if they settle on the side of the log, they bore across the grain for a short distance, usually within 2 inches,

then turn the direction of their operations so as to work with the grain, Fig. 45. As the worm increases in size it, of course, enlarges the diameter of its hole which thereby becomes conical in shape, as shown in Fig. 45. The much elongated body and siphons, Fig. 45, *ss*, extend posteriorly to the opening of the tube and the latter serve to conduct a

FIG. 47.—A chiton. $\times 1$.

stream of water to the animal (just as in ordinary Lamellibranchs) from which food is extracted in the form of microscopic organisms. At the base of the siphons are two small calcareous bodies known as *pallets*, Fig. 45, *p*, which serve to close the opening of the burrow against an enemy or to retain the water should the low tide leave the wood exposed. The method of boring of ship-worms has been

FIG. 48.—
Elephant's
tusk shell,
Dentalium.
 $\times 1$.

a much debated question; it is apparently accomplished by the rasping action of the posterior edges of the valves as they are rocked back and forth by the alternate action of the anterior and posterior adductor muscles, the shell being pressed against the end of the burrow by the cupping action of the foot. The particles of wood that are rasped away are ingested and thus passed out of the burrow, but whether the animal derives any nourishment from them is a debated question.

While the introduction of steel ships and the sheathing of wooden ones with metal have largely diminished the havoc wrought by these molluscan pests, still the destruction of small boats and especially of docks and piles, particularly in the tropical and subtropical waters, is often a serious matter. Various preventive methods have been tried,

such as soaking the wood in creosote and other materials but they all seem to give only temporary relief. In the case of docks and wharves the difficulty is being overcome, in many places, by the use of concrete.

The cephalopods, Figs. 46 and 46a, are of comparatively little economic importance. The squid are used by fishermen for bait and are an important food for fishes. The rough white cuttle bone is used in bird cages, and the well-known pigment, sepia, is made from the ink of certain cephalopods, *Sepia* in particular.

The Amphineura and the **Scaphopods** are of practically no economic importance other than as zoological specimens.

CHAPTER IX

ARTHROPODA

This is a very large phylum of usually comparatively small animals; there are more species here represented than in all the other phyla combined. As their name indicates, they are characterized as the first animals yet studied that have regularly jointed appendages. They are like the annelids in being segmented, in having a mouth at one end and anus at the other; and in having a dorsal brain and a ventral, ganglionated nerve cord. They usually have striated muscle fibres, and are almost always lacking in cilia. The body cavity is largely represented by blood sinuses in free communication with the vascular system. The classification is extensive but the most important classes are as follows:

FIG. 49.—A water flea, *Cyclops*.
×10. a^1 , 1st antenna; a^2 , 2d antenna; e , eye; es , egg sac; od , oviduct; ov , ovary; t^3 , 3d somite; ut , uterus.

I. **Crustacea**, Figs. 49, 50, 51, 53, 54 and 55. These are arthropods in which four or five anterior segments are fused to form the head, while the rest of the segments may usually be divided into two regions, the thorax and the abdomen. Some of the thoracic segments may be fused with the head to form a cephalothorax, as in the crayfish. The head bears a pair of compound eyes, sometimes a median eye. The thoracic and abdominal appendages are variously modified as claws, legs, fins, accessory reproductive organs, etc.; the typical appendage is biramous: the body is covered with a variously modified exoskeleton of chitin. Respiration is by means of gills or through the general body integument.

The circulatory organs consist of a contractile heart, a series of arteries and afferent sinuses and veins. The excretory organs are modified nephridia known as shell glands or green glands, located in and opening from the anterior part of the body. The nervous system consists of the brain, united by the circumoesophageal connectives with the ventral, ganglionated nerve cord. Sexes are separate or united; parthenogenesis is common.

The class is divided into two subclasses, the *Entomostraca* and the *Malacostraca*. The former includes the smaller, simpler types, such as water fleas, barnacles, etc., Figs. 49, 50, and 51; the latter includes the larger, more highly organized forms such as crayfish, crabs, lobsters, etc., some of which may be several feet in extreme length, Figs. 53 and 54.

FIG. 50.—Goose barnacle, *Lepas* sp. $\times \frac{1}{2}$.

II. **Onychophora**, Fig. 52. This class includes the curious caterpillar, like genus, *Peripatus*, which is interesting as having characteristics of both the Arthropods and the Annelids—a sort of “connecting type.”

III. **Myriapoda**, Figs. 56, 57 and 58. These are the centipedes and millipedes. They have many of the characteristics of the insects. There is a distinct head, bearing jointed antennæ; a pair of eyes and two or three pairs of jaws. The rest of the body is not marked off into different regions, but is divided into many segments, which in some species bear a single pair of appendages each (centipedes) and in other cases two pairs of appendages each (millipedes). They breathe by a system of trachea, like those of insects, opening to the exterior through stigmata on the lateral or ventral side of the body.

IV. **Insects**.—These are the grasshoppers, bees, flies, beetles, butterflies, dragon-flies, etc. It is the largest of all the groups of animals,

both in number of species and, possibly, in the number of individuals, with the probable exception of the Protozoa. In some ways the insects are the most highly organized of the invertebrates, and exhibit an intelligence far superior to that of many of the lower vertebrates.

It is a very distinctive group, without the wide variations in structure seen, for example, among the Crustacea; their name "Hexapod"

FIG. 51.—Acorn barnacle, *Balanus* sp. $\times 1$.

indicates one of their most marked characteristics, the invariable possession of six legs, born on the thorax. There are usually two pairs of wings, also born on the thorax. The body is distinctly divided into three regions, head, thorax and abdomen. The respiratory organs are branching air-tubes, or trachea, extending all through the body. The

FIG. 52.—*Peripatus capensis*, drawn from life. Somewhat enlarged. (From Hegner, College Zoology, after Sedgwick.)

eggs usually hatch into a grub or caterpillar, and undergo a marked metamorphosis in development to the adult condition. The adult is terrestrial or aerial, less often aquatic, but the larval stages of many forms are strictly aquatic. Some forms, bees, ants, etc.; form complex communities, with marked polymorphism.

V. **Arachnida**, Figs. 59 to 63. This rather heterogeneous class includes the spiders, scorpions, mites, ticks, king-crabs, etc.; though the

classification of some of these is uncertain. There is usually a cephalothorax and an abdomen; in some cases these two regions are fused. There are no antennæ in the adult. The cephalothorax bears sessile and usually simple eyes. The first pair of cephalothoracic appendages are the cheliceræ; the second pair are the pedipalpi; posterior to these are four pairs of legs. The respiratory organs are sometimes trachea, sometimes book-lungs, sometimes leaf-like external gills. The sexes are usually separate and there is no metamorphosis.

Crustacea.—*The American lobster, Homarus americanus.* This is probably the most important of our crustacea. As a laboratory form it is now rather expensive for large classes, but since the crayfish, Fig. 53, is almost an exact anatomical copy of *Homarus*, on a small scale, it is usually used for dissection purposes.

The Atlantic Coast of North America is the greatest lobster ground in the world, though the lobster industry of western Europe is also important. The species under discussion is found from Labrador to North Carolina, but it is exceedingly rare toward the southern limit of its range; Maine and Massachusetts are the centre of the lobster industry. The Pilgrims found the Indians using the lobster for food and ever since that time it has been one of our most highly prized sea-foods. It is said the Pilgrims paid their debts in England from the products of their fisheries.

Like so many of the natural resources of the country, all the natural lobster beds of the Atlantic are now more or less depleted and the price of lobsters has risen accordingly; a lobster that could be bought, a generation ago, for 5 cents will now bring a dollar or more. In Canada alone 100,000,000 lobsters have been caught in a year. The total catch in the United States in 1892 was about $23\frac{1}{4}$ million pounds; in 1905 it was about $11\frac{3}{4}$ million pounds, which sold for more money than the catch of 1892.

Some of the older accounts described monster lobsters that were "5 or 6 feet long," this probably meant with the claws extended straight in front of the head, which about doubles the length as now measured from the tip of rostrum to tip of tail. The largest authentic measurements that we have give a length, from rostrum to tail, of $23\frac{3}{4}$ inches, and a weight of 34 pounds. As a medium-sized lobster weighs only five or six pounds, it will be seen that this 34-pound specimen was a monster. The European lobster, *Homarus gammarus*,

which is very similar to the American form, is said to be lighter in proportion to its length than the latter form.

As to the age to which lobsters live we have but little data, Herrick (97) thinks one of the giant lobsters may be half a century old. A 10-inch female may be five years or more old. As in the crayfish the female lobster carries at certain seasons, a great mass of eggs with her, glued to the swimmerets on the ventral surface of the abdomen by a secretion of the oviducts, such a female is known as a "berried" lobster and may carry 10,000 or more eggs. These eggs are carried until they hatch into tiny embryos that swim to the surface and look quite different from the adult lobster. After a long series of molts the growing lobsters gradually take on the adult form and sink to the bottom where they live. This process of molting is general among the Crustacea. Being inclosed in an inelastic chitinous exoskeleton the lobster can grow only by periodically shedding this exoskeleton and then expanding rapidly before the new exoskeleton hardens; the growth at one molt is sometimes surprisingly great. Molting among the adults is most common in the late summer and early fall. The process may take from 5 to 30 minutes or longer and it is generally five or six weeks before the new shell is thoroughly hardened. The American lobster breeds biannually, though it is possible that annual broods may sometimes be produced.

On land the lobster, owing to its weight and relatively weak legs is almost helpless, but in water it crawls about actively on the bottom and swims backward, by flopping its tail, at a remarkable rapid rate; one specimen was seen to swim 25 feet in less than one second. Variations of temperature, food supply, etc., cause the lobster to migrate from shallower to deeper water and back, and even to travel along the coast for some miles. It may hide itself beneath rocks and such things or even dig a burrow in the mud, somewhat after the manner of the crayfish. It is carnivorous in habits and feeds most actively during the warmer seasons.

In the early days the Indians caught lobsters by spearing them. In Europe they were caught by means of long wooden tongs. The method universally employed at present is by the use of traps or "pots," built on the plan of the typical rat-trap, with a conical entrance at one or both ends. Traps of this sort have been used in Europe for centuries, being known in Scotland as "lobster creels." They were

formerly of the wicker basket type, but are now usually made of lath. They may be rectangular, cylindrical or semicylindrical, and are from $2\frac{1}{2}$ to 4 feet long, about 2 feet wide and $1\frac{1}{2}$ feet high. The ends are of heavy mesh in the form of an inverted cone with an entrance hole about 6 inches in diameter, so that the lobster can easily crawl in but cannot readily find its way out again. The slats are nailed about 2 inches apart on some sort of frame and have a door in the top through which the lobsters may be removed.

The traps are baited with herring, halibut, fish-heads, etc.; they are sunk to the bottom with stones or other weights and are secured with a rope long enough to reach the surface of the water where it is attached to a wooden buoy, painted with the owner's name or color. The traps are usually set at a short distance from the shore, usually in 1 to 10 fathoms of water in summer, but in winter they may be out 5 or 6 miles, in 25 to 50 fathoms. The traps are pulled as often as once or twice a day in summer, but in stormy winter weather, a week or two may pass before they can be visited; many are lost in winter storms. After removal from the traps the lobsters may be kept in live boxes until ready for shipment, which is done by packing them in wet sea-weed, with ice below them in warm weather; the ice must be beneath as the dipping of the fresh water from the melting ice is fatal; the claws may be plugged or tied to prevent their being used. In this condition they may be shipped almost any reasonable distance. The longest distance they have been shipped was from England to New Zealand, about 12,000 miles; several such shipments have been made with comparatively little loss of life; each lobster in this case, however, was put into a separate wooden compartment with clear, cool, aerated water and was fed during the journey, which lasted, in one case, 54 days.

Several lots of American lobsters have been transported across the continent and planted along the Pacific Coast from Monterey Bay to Puget Sound; while no definite results seem yet to have been attained it is probable that the experiment will eventually prove successful.

When the supply of lobsters became seriously diminished means were sought to aid nature to replenish the waters that had been so thoughtlessly robbed.

The most obvious thing to do was to strip the eggs from the berried lobsters and carry them through the earlier stages of their development

in the safety of hatching jars. This is now done at numerous hatcheries along the coast, one of the largest of which is at Boothbay Harbor, Maine. The eggs after being carefully scraped from the swimmerets of the female are put into glass jars where they are kept in running water and carefully tended until they hatch and, preferably, have reached the bottom-seeking stage, when they are taken out to sea and liberated at favorable localities along the coast. Many millions of such young lobsters are liberated each season.

Besides this rearing of young, other expedients are recommended and are being applied in some regions, as follows:

1. Have a standard trap with an entrance too small to admit the largest lobsters, which are thus saved for breeders, and with slats so far apart that lobsters less than 10 inches in length can escape.

2. License every lobster fisherman.

3. Protect the berried lobsters by forbidding their sale, and offer a bounty upon them at the hatcheries where they may be stripped. This bounty will tend to prevent dishonest fishermen from stripping the females and then selling them in the open markets.

4. Abolish the closed season and permit fishing throughout the year.

Spiny lobsters, genus *Palinurus*. These lobsters which are often large and spiny but are without claws are found in various parts of the world. *P. vulgaris*, the common spiny or rock lobster is common in southern and western Europe and is an important article of food. It's meat is largely confined to the thorax and abdomen and is said to be as delicious as that of the true lobsters.

P. interruptus is found on the western coast of North America and often reaches a considerable size.

Crayfish, or *Crawfish*, genus *Cambarus* (eastern U. S.) and *Astacus* (Europe and Pacific coast of U. S.), Fig. 53. These two genera, of which there are many species, have a greater economic importance, both positive and negative, than is commonly realized. The positive side will first be briefly discussed.

For many years they have been so extensively used as food in European countries that it has been profitable to rear them artificially. Their use in the U. S., though not so general, is increasing; for example, 16,000 pounds of *Cambarus* were sold from New Orleans Co., La., in a year, and over 55,000 pounds from Monroe Co., Fla. On the Pacific coast the larger genus, *Astacus*, is collected in large numbers,

165,000 pounds being sold in Oregon in one year; these are prepared for shipment by placing them alive in white wine and spices, and boiling for two minutes; they are then shipped in this liquid in tin containers.

The *Astacus* is not only larger but has larger claws and is more lobster-like than *Cambarus*, hence it brings better prices. It could doubtless be introduced into the east. The eggs are laid in the spring and the animal becomes sexually mature the following spring and reaches its full size in three or four years though these figures may vary considerably in different species and under different conditions. They can be easily raised in ponds, requiring merely air, fresh water and some sort of organic food; refuse animal and vegetable matter may be used.

FIG. 53.—Crayfish, *Cambarus* sp. $\times \frac{3}{4}$.

The damage done by crayfish, in certain sections, is very considerable, especially in the clay lands of Alabama and Mississippi. The crayfish often dig holes into the ground to a depth of several feet, with the excavated earth piled in a circular chimney at the orifice. In these clay lands the bottoms of the holes are always filled with water, making ideal homes for the animals. In an area of about 1000 square miles the crayfish very largely prevent the successful raising of cotton and corn. They damage the young plants just after they appear, generally by tearing off the tender cotyledons.

The number of crawfish in some of the infested areas may be seen from the fact that there may be 8000 to 12,000 holes to the acre, and on one plantation 27 barrels of crayfish were collected in a season.

It is sometimes the custom to pay negroes a barrel of flour or of corn for each barrel of crayfish collected. The Department of Agriculture investigated the problem and found various remedies. Apparently if they are persistently hunted at twilight, at night, or after a rain, they may be exterminated or so reduced in numbers as to be of little harm. The easiest way is to pass along the rows and systematically kill them with clubs or by stepping on them. If instead of this, they be collected, they may be either sold as food for man or they may be boiled, mixed with meal, and allowed to dry, when they make most excellent chicken feed.

There are various poisons that when introduced into the holes and then filled in, will destroy the animals and leave them buried. Chlorid of lime, (one pound to three gallons of water) is effective and cheap, but the mixing and hauling may make it as expensive as carbon bisulphid, which may be introduced into the hole with a long oil can, such as locomotive engineers use, after which the hole is closed by stepping on it. The cost of the carbon bisulphid will be from \$1 to \$2 per acre, or perhaps more in times of high prices, and the cost of the labor will perhaps be greater than the cost of the poison.

Crabs.—There are many kinds of crabs that are used for food by man. In the tropics several forms of land crabs are thus used, some of them being collected in large numbers as they migrate from the mountains to the sea to spawn.

In the United States it is the strictly aquatic forms, *Callinectes* and others, that are used, Fig. 54. These are used both as “hard-shell” and as “soft-shell” crabs; the former is the crab in its normal condition with the hard, chitinous exoskeleton; the latter is simply a crab that has recently molted, whose exoskeleton has not yet hardened. The hard-shell crab is caught either in traps, like those used for lobsters, or on lines baited with stale meat, the entrails of fowls, etc. No hook is used in “crabbing;” the crabber simply supplies himself with the necessary bait, with a dip-net and with a quantity of cheap twine. The twine is cut into suitable lengths and is tied to pieces of bait and the latter hung into the water from the side of the boat or dock, or at intervals along a long “trot line.” The fisherman goes from string to string and pulls each up slowly until the bait is near the surface of the water, when, with a quick dip of the net, he captures the crab or crabs that may be clinging to the meat with

their claws. The crabs will drop off if the bait be raised out of the water. Sometimes two or three or even more crabs will be taken with one sweep of the net. With a dozen or less lines one person may keep continually at work and if the crabbing be good he will soon have more than he can carry home. The soft-shell crab does not allow itself to be thus easily captured, and hence is more of a luxury. Being unprotected with a hard shell it seeks safety by hiding itself under the sea-grass, etc., at the bottom, where it must be sought with a long handled net or by wading along the shore where the water is shallow.

FIG. 54.—Common rock crab, *Cancer irroratus*. $\times \frac{1}{2}$.

The hard-shell crab is usually cooked by throwing it alive into boiling water, after which the meat, with the exception of certain parts, is picked out, seasoned and then baked, either in cakes or in the cleaned shells of the crab; such "deviled" crabs are very common in all parts of the country that are at all accessible to the coast. The soft-shell crabs do not have to be removed from their shells, but are eaten shell and all. Like some other sea-foods, crab meat, unless carefully prepared, quickly spoils and causes violent sickness.

Like our other supposedly inexhaustible resources, the crabs have begun to become scarce, so that certain laws as to size, closed seasons, berried crabs, licenses for fishermen, etc., have been passed to protect this important industry before it is too late.

Shrimps and Prawns, Fig. 55, are usually small crustacea, of several species, found in various parts of the world. They are used in this country mainly for salads, and look like small, soft crayfish. In the tropics, the natives are often seen wading about in the shallow waters with a hand net that they sweep through the aquatic grasses, to collect these small (sometimes not over an inch long) Crustacea that are dried

FIG. 55.—A shrimp, *Palaemon* sp. $\times \frac{3}{4}$.

in the sun and taken to market. In many parts of Europe they are extensively used for food. In cans they may be transported any distance and will keep indefinitely, and it is in this condition that they are usually seen.

Onychophora and Myriapoda.—These two classes are of so little economic importance that they may be dismissed with but a few words.

FIG. 56.—Centipede, *Scolopendra* sp. $\times \frac{3}{4}$.

The former class probably has no economic importance other than its value for museum and scientific purposes.

The centipedes, belonging to the latter class, are said to be eaten by the South American Indians. The myriapods are very generally feared though most of them are quite harmless. The large tropical centipedes, genus *Scolopendra*, Fig. 56, are poisonous to man, possibly fatally so at times; they may reach a length of 18 inches. The well-

known house centipede, *Scutigera forceps*, Fig. 57, is supposed by many to be very poisonous and, according to Marlatt, it has a decidedly disagreeable bite, which may be alleviated by the prompt application of ammonia; it feeds on roaches, flies and other insects, probably including bedbugs, so that it is a useful animal except for its poisonous bite.

FIG. 57.—House centipede, *Scutigera forceps*. $\times \frac{2}{3}$. (From Marlatt, *The House Centipede*.)

The millipedes, *Julus* and others, Fig. 58, are harmless to man but are often destructive to crops.

Arachnida.—The economic importance of this group, which includes some animals of great zoological interest, is not great and is very largely negative.

Spiders, Figs. 59 and 60. Some of the web-building spiders have a slight positive importance from the fact that the fine threads that they

FIG. 58.—A milliped, *Julus*. $\times \frac{3}{4}$.

spin may be wound upon a reel and used for the cross-hairs of surveying and other instruments of precision. They are also of some value as destroyers of insects. Popularly the spiders are, as a group, supposed to be poisonous, even dangerously so. Students of spiders, however, have generally maintained that, with the exception of the huge, hairy tarantulas of warm climates, the North American spiders are harmless. Recently Kellogg (102) has pointed out that the notorious *black widow*

spider, *Latrodectus mactans*, Fig. 60, really is at times, dangerously poisonous to man. *Latrodectus* is widely distributed over the earth and is generally feared. In the Americas there are three species of this genus, the best known being the one named above, which is found from the northern part of the United States to the southern end of South America, it is common in our southern and southwestern states. The male has an elliptical abdomen and is about 12 mm. in length. It is a "sooty-black or dark brown color with a conspicuous small blotch

or blotches of vivid red on the under side of the abdomen. This blotch or pair of fusing blotches has the rough outline of an hour-glass. However it varies much in shape." The position and vivid color of this spot on the dark body are characteristic.

Kellogg describes a case in California in which most serious results followed the bite of this spider. Enormous swelling of the bitten organ, intense pains with cramp, labored respiration, slowed heart-beat, etc., were noted. A cat injected with an attenuated dose of the poison died in 10 minutes, other animals reacted strongly.

"A diadem spider of 1.4 gr. (weight), contains sufficient poison to destroy completely all the corpuscles in 2.5 liters of rabbit's blood."

FIG. 59.—"Tarantula" spider, sp. $\times \frac{2}{3}$.

Doubtless the effects of the bite of these spiders are more marked with some persons than with others and with the same person at different times. Kobert says they may "produce by their bite the most serious general results, and are capable of killing even men." The bite of the *Tarantula* may often be painful without being serious.

Of poisonous spiders Comstock (93) says: "The so-called Tarantula (Heteropoda) that is frequently brought to the North in bunches of bananas is often described as the cause of serious injury. This however, though a large spider, is an inoffensive one. Mr.

John T. Lloyd informs me that he has collected scores of specimens of this species with his hands in Samoa, where it is abundant, and has never been bitten by it.

A

B

C

FIG. 60.—A, black widow spider, *Latrodectus mactans*, female. $\times 3$. B, ventral view of same; C, body of male. $\times 3$. (From Comstock, *The Spider Book*.)

“Although we have in the North no spider that is to be feared, it is quite possible that in the South it is different. I confess that I should not like to be bitten by one of the larger Tarantulas of that region, although I know of no well-authenticated case of a person being bitten by one.

"The spiders of the genus *Latrodectus*, of which we have a common representative in the South, are feared wherever they occur, and it is quite possible they are more venomous than other spiders."

Scorpions, Fig. 61. These curious and dreaded animals with the "sting" at the end of the tail are often abundant in tropical and sub-tropical countries. The sting of a large 10-inch specimen may be serious; that of an ordinary 3- or 4-inch animal is usually about as severe as the sting of a wasp or hornet.

FIG. 61.—Scorpion, *Centruroides* sp. $\times \frac{3}{4}$.

There are several small arachnids, of the order *Acarina*, that are external parasites on man and other animals and are sometimes a serious pest. For example, the tiny harvest-mites or *chiggers* burrow into the skin of man and cause most annoying itching; they may be killed by rubbing the skin with kerosene, a 1 per cent. solution of carbolic acid, or other similar substance.

Poultry and cattle ticks, Fig. 62, cause injury to their hosts, the latter in particular as a carrier of the germ of the Texas cattle fever, as described in connection with the Protozoa.

The *follicle mites*, Fig. 62, C, live in the hair follicles and sweat-ducts of man and cause "blackheads;" the itch-mite, Fig. 62, D, by burrowing in the skin produces intense itching, and the sheep-scab mite produces scabs on the skin of sheep, cattle and horses.

King-crab or *horse-shoe crab*, *Limulus*, Fig. 63. This is perhaps the largest of living arachnids, reaching an extreme length of 2 feet. It is one of the few members of this class that live in the sea, where it is found crawling or slowly swimming over the sand or mud flats along shore. It is interesting zoologically and is said to be fairly good as food, though it is not very commonly eaten. It is sometimes classed with the Crustacea, as its affinities are uncertain. Along the shores of Delaware Bay it is caught by the ton, as it comes ashore to spawn; it is used as food for hogs and as a fertilizer.

Insecta.—There are more species of insects known than of all the other groups of animals combined. Their numbers, though variously estimated, run well up in the hundreds of thousands, and the number of undescribed species can hardly be estimated. The study of this enormous class is a large department of science in itself, *Entomology*, and one of great importance largely because, as a class, insects are highly destructive to vegetation and injurious to man in other ways.

It has been estimated that the direct annual loss in the United States due to insects is about one billion dollars, besides the losses due to disease-producing and other noxious forms.

FIG. 62.—Acarina, enlarged. C, follicle mite, *Demodex folliculorum*. D, itch mite, *Sarcoptes scapici*. E, sheep-scab mite, *Psoroptes communis* var. *ovis*. (From Hegner, *College Zoology*, C and D, after Sedgwick, C, from Mengin, D, from Güdden, E, from Osborn.)

The relation of insects to agriculture is too large a subject to even touch upon in a book like this; there are whole libraries of entomology dealing with this phase of economic zoology. It may be interesting, however, to briefly discuss a few insects that are harmful to man in other ways, and a few that are highly beneficial.

Mosquitoes.—The part played by mosquitoes in the transmission to man of malaria, yellow fever, etc., has already been noted in Chapter I. Though to most people all mosquitoes “look alike” there are several hundred species, and according to Felt (95) there are 50 or more species in New York State. Of these, two or three genera, have already been mentioned; *Culex*, the common non-malarial forms; *Anopheles*, the malarial mosquito; and *Stegomyia*, the yellow-fever mosquito. The last named is ordinarily found only in tropical or sub-tropical

regions, and is nearly always found in or about houses. It is sometimes called the "day mosquito" from its habit of biting in the daytime. This mosquito, Fig. 64, is black with conspicuous white markings; the legs and abdomen are banded with white, while the thorax is marked with white in the form of a lyre.

Anopheles, the other important disease carrier may be distinguished from the non-malarial forms as follows: it has spotted wings, while most

of the other forms have clear wings; it has long mouth palpi, shown ventral to the proboscis in Fig. 65; and when at rest the head and proboscis are in one line with the body and form a considerable angle with the surface, instead of being nearly parallel to it, Fig. 65; the position of the breathing larva, close to the surface of the water, is shown in the upper half of Fig. 66.

As is well known it is the female mosquito that bites, possibly the male, in most cases, takes no food. The males may often be recognized by their large, feathery antennæ, which have given them the name of "woolly heads." It is commonly supposed that they live upon blood, but it is likely that not one in a million ever tastes blood; their natural food is generally the juices of

FIG. 63.—King or horse-shoe crab, *Limulus Polyphemus*. $\times \frac{1}{4}$.

soft plants, which accounts for the beneficial results of cutting down rank vegetation in the neighborhood of mosquito-infested houses. They may be kept in captivity by feeding them on ripe bananas.

While there is some variation in the life-histories of the different species, the general process is about as follows: the female lays a number of eggs, either singly or in masses that float on the surface of the water; there may be several hundred eggs in one of these masses or "rafts," Fig. 67. The water may be fresh or salt, clean or foul; even cess-pools or wet mud may serve for some species. The water may be a lake,

or it may be a few ounces in an upturned tomato can; it must, however, be still or the female cannot light upon its surface to deposit her eggs, hence rapid streams do not breed mosquitoes. The eggs hatch, depending on the species and upon the conditions, as soon as 16 hours after being laid, perhaps even sooner. The larvæ, Fig. 66 and 67,

FIG. 64.—Yellow-fever mosquito, *Stegomyia calopus (faciata)*. (After Doane, *Insects and Diseases*, by Newstead.)

work out of the lower side of the eggs and begin their life as wrigglers, coming to the surface at frequent intervals to breathe through the air-tube near the end of the tail; this larval life may last from one to three or more weeks, during which time the insect molts several times until

it finally reaches the pupa stage, Fig. 68, when it stops feeding and lies quietly on the surface of the water, breathing through tubes situated on the dorsal side of the thorax, instead of near the end of the abdomen. The larva is heavier than water and has to wiggle actively to get to the surface to breathe, the pupa is lighter than water and lies without effort at the surface. The pupal stage may last from two to six days or more. When the adult is ready to emerge the pupal skin splits down the back and the mosquito slowly escapes; it may take

FIG. 65.—Resting position on vertical wall of *Culex* (left) and *Anopheles* (right). (From Howard, *Mosquitoes of the United States*, after the *British Medical Journal*.) Enlarged.

several minutes for the animal to issue from the old skin and for its wings to dry and harden enough for flight; during this time it stands on the floating pupa skin and is, of course, easily upset and drowned by the least roughness of the surface of the water; this is another reason why mosquitoes do not breed in running water.

How long the adult mosquito lives is difficult to determine; some of them hibernate all winter, but in confinement they usually die rather soon.

Some species fly for considerable distances, but, as a rule, they remain very close to their place of birth, so that it may even be possible

to rid one suburban residence of the pest while the next place is still infested. They are delicate creatures and seldom attempt to fly in a strong breeze, but a very gentle breeze may carry them for a consider-

FIG. 66.—Larva of *Anopheles* in feeding and breathing position, just below the surface of the water (upper figure). Larva of *Culex* in breathing position, at an angle to the surface (lower figure). Enlarged. (From Howard, *Mosquitoes of the United States*.)

able distance. They are often carried for many miles in railway trains and other public conveyances to regions ordinarily free from them.

Knowing their breeding habits, the methods of mosquito control will immediately suggest themselves; the first is to destroy all breeding places; this may mean the drainage of swamps and ponds or it may sim-

ply mean the overturning of tin cans, tubs, etc.; even a gutter on a roof that has become clogged with leaves and dirt may breed mosquitoes by the thousand. If the water cannot be led away nor poured out the problem may be handled in other ways; ponds that cannot be drained may be sprayed with kerosene or crude petroleum, about 1 ounce per 15 square feet once a month during the mosquito season; or if this be impracticable or undesirable, the pond may be stocked with minnows or other small fish that will feed upon the larval mosquitoes. These

FIG. 67.—*Culex pungens*; egg mass, with more enlarged eggs at left; young larvæ below. Enlarged. (From Howard, *Mosquitoes of the United States*.)

small fish will be much more effective if the sloping banks of the pond be cut away so that the larvæ may not escape the fish by going into the very shallow water close to shore.

Dragon flies are excellent mosquito destroyers, as their larvæ eat the larval mosquitoes and the adults catch and eat the adult mosquitoes. Rain barrels, and cisterns can usually be screened to keep out the adult mosquitoes and this is one of the important proceedings in crusades against the yellow fever mosquitoes in the South.

In some of the great swamps of the South, the extermination of mosquitoes is a difficult, if not impossible, task; but in most localities

a pest of mosquitoes is a reflection upon the ownership or upon the local government.

The house-fly, Musca domestica, Fig. 69. An even more serious pest than the mosquitoes are the flies, the house-fly, in particular. This only too familiar animal has, until recent years, been regarded as rather

FIG. 68.—*Culex pungens*; full-grown larva at left; pupa at right. Enlarged. (From Howard, *Mosquitoes of the United States*.)

an innocent little nuisance that tickled us when we wanted to sleep, and got into our food. That this idea is still somewhat prevalent is seen in the attitude of the average person toward flies and roaches; if the comparatively harmless roach finds its way into our soup we throw

it away in disgust, but many a housekeeper will fish half a dozen filthy flies out of the milk pitcher and "shoo" them off the cake without a thought. To most persons "all flies look alike" and they do not realize the number of species that are a pest to man and to the lower animals.

FIG. 69.—The house-fly, *Musca domestica*. (After Doane, *Insects and Disease*.)

For example, the *sheep bot-flies* lay their eggs in the nostrils of sheep and when the larvæ hatch they crawl up into the frontal sinus causing great suffering to the sheep and loss to the owner.

The *horse bot-flies* lay their eggs on the body of the horse and when

the horse licks himself the eggs get into his alimentary canal where they hatch into maggot-like larvæ.

The bot-fly larvæ of cattle, the *ox warbles*, get into the alimentary canal in the same way, but instead of lodging in the stomach they bur-

FIG. 70.—Wing of stable-fly, *Stomoxys calcitrans*. (After Doane, *Insects and Disease*.)

row out through the esophagus until they come to lie under the skin of the back; here they develop and make ugly sores, and when mature they cut through the skin, fall to the ground and complete their develop-

FIG. 71.—Wing of house-fly, showing adhering dirt in which bacteria may lodge. (After Doane, *Insects and Disease*.)

ment. The holes they make in escaping injure or even ruin the skin for leather.

The *human bot* or screw-worm flies lay their eggs in sores on the body; the eggs very quickly hatch and the maggots burrow under the skin causing painful and even fatal results.

The widely prevalent and dangerous disease of horses and cattle in the orient, *surra*, is probably conveyed by flies, as was noted before. Numerous other illustrations of the injury wrought by various species of flies might be given.

Anyone will recognize the difference between the house-fly and the blue bottle fly or the horse-fly or, perhaps, even between it and the similar stable-fly. Fig. 69 is an excellent representation of the house-fly, and a comparison of Figs. 70 and 71 will show one of the means of distinguishing it from the similar stable-fly; it will be noticed that the lowest or most posterior of the three long veins in the wing of the house-fly bends upward or cephalad at almost a right angle while the corre-

FIG. 72.—Last three segments of the leg of the house-fly, showing claws, pulvillæ and hairs. (After Doane, *Insects and Disease*.)

sponding vein in the stable-fly's wing has only a wide curve toward its distal end.

What is the reason for the present crusade against the house-fly? It is not merely because it is such a filthy little animal, as will be presently noted, but because it is one of the worst carriers of pathogenic bacteria that we have; this is particularly true of the germ of typhoid fever, but it is thought that several other diseases are spread in the same way, such as tuberculosis, cholera, dysentery, smallpox, diphtheria, etc. It has been suggested that we call the house-fly the *typhoid fly* to remind people of its dangerous habits. The fly is an ideal instrument for carrying bacteria, which it does in two ways; it may eat them with its food and then deposit them on our food or dishes in its excrement as "fly specks," or it may carry them mechanically entan-

gled in the hairs and folds of its proboscis, wings or legs. The wings of a fly when examined under moderate powers of the microscope are found to be covered with thousands of tiny, stiff hairs, too small to show in the figures here represented, and the legs are covered with numerous larger hairs as shown in Fig. 72. In the dirt (see Fig. 71) that collects among these hairs is room for millions of bacteria, so that in a series of

FIG. 73.—Eggs of the house-fly. $\times 1$. (From Howard, *House Flies*, after Newstead.)

experiments it was found that on an average a single fly may carry about 1,250,000 bacteria; these bacteria may be harmless but they are often the germs of deadly diseases. Let such a fly crawl across a culture dish and an astonishing trail of bacteria will develop along its course. Where these bacteria are collected is easily understood when the breeding

habits of the house-fly are studied. Nearly anyone knows that the unpleasant maggots seen in decaying flesh are the larvæ of flies, hatched from the eggs laid in this flesh by the adult females in order that these larvæ may have food to eat while they are developing into the pupa or chrysalis stage. These maggots may or may not be the larvæ of house-flies, probably they are mostly those of other species; but anyone may see the whole process by watching a piece of stale meat some summer's day. Usually one will not have to wait very long until a fly will light upon the meat and will proceed to deposit her elongated, white eggs, possibly at the rate of four or five per minute until a hundred or more have been laid, Fig. 73. If the meat be kept moist and warm the next day will probably see it swarming with tiny white maggots; these larvæ, in a few days, will grow to full size, will surround themselves with little cases and become pupæ. If the meat be in a covered vessel the flies that emerge in a week or more, from these chrysalises, will be caught and they will in turn, lay a new lot of eggs, though it may be a couple of weeks after hatching before the flies become sexually mature and are able to lay eggs. Since each fly may lay one hundred or more eggs in each of five or six lots per year, and since the whole life cycle, from adult to the next generation of adults, may take place in three or four weeks, it will be seen that by the end of the summer the descendants of the first few flies are to be numbered by millions; hence the importance of "swatting" the first flies as they emerge from their hibernation quarters. The life history of the house-fly is about as outlined above, except that its favorite breeding place seems to be in damp horse-manure, though it will breed in almost any kind of filth or decaying organic matter; for this reason the name "filth" fly has been suggested. It is perfectly obvious that if the eggs be laid, as they often are, in human excrement from a person who is suffering or has recently suffered from typhoid fever the flies, as they hatch and crawl out through the filth, may be covered with typhoid fever germs which may be carried to another person in various ways. The disgraceful epidemics of typhoid fever that raged in our army camps during the Spanish American war were probably largely due to the lack of care in protecting the soldiers against this kind of infection. In a similar way flies, by feeding on the sputum (as they often do) of tuberculous persons, may carry the germs to other persons. Knowing, now, the habits of the house-fly the methods of fighting this serious pest are more or less obvious; they consist chiefly

in destroying its breeding places, and secondarily in the use of fly-traps, fly-paper, etc. In towns and cities this is comparatively easy; on the farm it is far more difficult. The screening of privies and cesspools, and the close covering of garbage cans is generally not difficult.

It is the handling of manure, particularly horse manure, that is difficult. In cities it is comparatively easy to compel owners of private and livery stables to keep all manure in closely covered bins so that flies cannot gain access to it; but on the farm this is far more

FIG. 74.—Maggot trap for control of house-flies, showing the concrete basin of water in which the larvæ are drowned, and wooden platform on which the manure is piled. (*From Howard, House-Flies, after Hutchinson.*)

difficult. If not practicable to keep it in bins the manure should either be spread on the fields every day or two where it will dry and kill the fly eggs and larvæ, or it must be sprinkled with some substance that will kill the flies without injuring the manure; various chemicals have been tried for this purpose with the conclusion that powdered hellebore (using $\frac{1}{2}$ lb. to 10 gallons of water for each 8 bushels of manure) is the best substance, though its cost, about 0.69 cents per bushel of manure, makes it fairly expensive. Perhaps the best, and in the end the cheapest, solution of the problem is to build a "maggot trap" to hold the

manure; this consists of a wooden platform of slats over a shallow concrete tank of water. The manure is piled on this platform and is kept wet; the maggots in their migrations fall through the slats and drown in the water. This very simple arrangement, Fig. 74, is said to destroy 99 per cent. of the fly larvæ in the manure. Details of construction and operation may be obtained from the U. S. Department of Agriculture.

The trapping and poisoning of the adult fly is understood by most persons and a vigorous campaign along this line undoubtedly helps

FIG. 75.—Termites. A, male or king of *Termes* slightly enlarged; B, female or queen of *Termes*, slightly enlarged. C, worker and D, soldier of *Termes*, considerably enlarged. (From Hegner, *College Zoology*, after *Cambridge Natural History*, C and D from Grassi.)

diminish the numbers of flies, though not so effectively as the methods just mentioned. This subject is also treated in the bulletins issued by the Department of Agriculture.

Termites or “white ants,” Fig. 75.—These interesting insects are not true ants; they are variously classified by different writers, but are usually placed in the order Neuroptera. There are a hundred or more described species and many species that have never been named. Their colonial mode of life and their superficial resemblance to ants have doubtless given them the name “white ants.” As among the hymenopterous colonies, the termites exhibit several forms of indi-

FIG. 76.—Work of western white ant, *Calotermes* sp., in Mexican walnut, Catalina Mountains, Arizona. (From Snyder, *White Ants as Pests in the United States and Methods of Preventing their Damage.*)

viduals, Fig. 75, the workers, soldiers, kings and queens; of these the workers are the most numerous and are the ones that do the damage. In some tropical forms the queen is many times as large as the other forms. In warm places eggs may be laid at any time during the year. At times, usually spring or fall, certain winged sexual individuals leave the nest in large numbers and swarm in new places to start new colonies. These "flying" ants are often destroyed in enormous numbers by birds.

Termites are natural wood destroyers and live in colonies of usually several thousand individuals in decaying logs, dead trees, foundation

FIG. 77.—Book from a library at Van Buren, Ark., ruined by white ants. (From Snyder, *White Ants as Pests in the United States and Methods of Preventing their Damage.*)

timbers of houses, fences and other wood in contact with the ground, and in complicated underground passages usually found beneath wood or other débris. They sometimes work from these colonies up into the lower floors of houses where they riddle the floors and joists with their passages until nothing but a shell is left and their presence is first made known by the sudden collapse of some timber. It is in this destruction of woodwork that the white ants do their greatest damage, especially to timber that is in contact with moist ground, and particularly in tropical and sub-tropical regions, the ravages have been reported as

far north as New Hampshire and Michigan. In the tropics the damage is so serious that in some places all important buildings are being constructed entirely of concrete. In hard wood their main passages usually follow the course of the grain, as shown in Fig. 76.

Besides the damage done to wood, just noted, many other products are injured; for example: books, Fig. 77; clothing, food, etc., especially if stored in damp, dark, poorly ventilated cellars; shrubs, flowers and nursery stock; and field crops of various kinds.

As in most cases, "an ounce of prevention is worth a pound of cure," and it is better to protect property against inroads of white ants than to drive them out after they have come. T. E. Snyder, (1906) of the U. S. Department of Agriculture gives the following summarized recommendations, both for the "prevention" and for the "cure:"

"How Buildings Should be Constructed so as to be 'White Ant Proof.'

"Where possible, make the foundation of buildings entirely of stone, brick, or concrete, including stone columns or pillars in the basement to support the floor above; make the walls and flooring in the basement or cellar also of concrete, and lay concrete floors on a gravel base. Fill in and round off points of juncture between concrete walls and flooring so that these will not meet at right angles.

"Where stone or concrete foundations are impracticable, use timber impregnated with coal-tar creosote.

"Never completely surround beams with mortar or brick; leave an air space around the beams to permit air circulation. Set beams on stone or on concrete, not in the earth or in moist concrete. Rest the supports of porches or steps on stone or concrete.

"Lay basement window sills and frames over concrete and do not allow the woodwork to come in contact with the ground. Never sink untreated timber in the ground or in moist concrete; let there be no wood in contact with the ground through which the termites may come up from subterranean galleries.

"Complete dryness of the foundation and basement walls and flooring is an important means of rendering buildings safe from attack; therefore, provide for air spaces between the ground and wooden flooring and lay concrete floors on a gravel base.

"In greenhouses, replace woodwork, wherever possible, with iron frames and concrete work. Treat necessary woodwork, before use, with a 1 per cent. solution of bichlorid of mercury.

"How to Eliminate White Ants Already Established in Buildings.

"Promptly examine the foundation timbers and other woodwork in the basement to determine the approximate point of entrance and the extent of damage already accomplished. After removing the damaged wood, drench the ground with kerosene oil.

"Break up the earthlike shelter tubes by means of which white ants are sometimes able to pass over the surface of impenetrable substances in order to reach woodwork, and drench the ground beneath with kerosene oil.

"Then replace damaged timber with rock, brick, or concrete; or, if this be impracticable, substitute, for the foundation, timbers treated with coal-tar creosote.

"Since termites always require access to damp earth, shut off this source of moisture, and the insects will not be able to extend the galleries farther and will perish."

Clothes Moths.—It is probable that these small moths have been a pest ever since man began clothing himself in skins and they are particularly mentioned in the older books of the Bible. They are supposed to be of Old World origin and to have been introduced into America in early Colonial days. They are common everywhere; in the warmer regions being destructive at all times while further north they begin their depredations with the advent of spring or early summer. The adults, like other lepidoptera, are quite harmless as they take no food in the winged state, the mouth-parts being rudimentary. Though the average housekeeper does not know this, it is perfectly proper to kill the tiny flitting moths since it prevents their laying eggs that will hatch into tiny larvæ or caterpillars, which are the destructive agents. The way in which these small caterpillars injure woolen goods, furs, etc., is only too familiar, so that nothing need be said of this.

The adults lay their eggs usually upon clothes or other fabrics that are not in daily use, especially if these materials are in dark places; and if not disturbed these eggs soon hatch into the larvæ that ruin the garments upon which they feed and from which they construct their tiny bag-like cocoons. Fig. 78 is the common species in the north; there are also the southern clothes moth, the common species from Maryland, south; and the tapestry moth, the rarest of the three, a more brightly colored form that feeds especially upon carpets, upholstering, and other heavy fabrics. The most important thing to know about all of these species is how to prevent their damage; this is a very simple matter if we remember that the adults cannot and the larvæ will not, eat paper.

Every housekeeper knows that cloths and other woollen goods that are in daily use are seldom if ever damaged and that frequent vigorous shaking and brushing of clothes not in use prevents their being eaten by moths; this means simply that the eggs, if they have been deposited on the clothes by the winged adults, are brushed off and destroyed before they have time to hatch into the feeding caterpillars.

The common method of putting away winter clothes in boxes or closets with moth-balls or other strong-smelling substances will be effective only if all eggs or larvæ have been removed from the clothes by vigorous brushing and shaking before putting into the box

FIG. 78.—The case-making clothes moth, *Tinea pellionella*; adult, larva, and larva in case. (From Marlatt, *The True Clothes Moth*, after Riley.)

The strong odor will probably keep the adults from coming through the cracks into the box to lay their eggs, but if the eggs are already there, they will probably hatch into the destructive larvæ which will not be affected by the smell.

As the smell of naphthalene and other repellants is often disagreeably persistent in clothes that have been so protected, it is well to know that it is entirely unnecessary to use these substances if the clothes be *tightly* wrapped in stout paper, *after* being thoroughly brushed. For years the writer has, each spring, packed his winter clothes in the pasteboard boxes used by tailors, and then tightly wrapped each box in several thicknesses of newspapers, creasing all corners to prevent the possible entry of the slender little moths. In no single case has any damage been found on opening these boxes in the fall. The

same results may be secured by gumming strips of paper over the joints of the boxes.

Upholstering of furniture, etc., that cannot be protected in this way while not in use during the summer may be protected by spraying with naphtha or benzine, every six or eight weeks, if precautions against danger from fire be taken with these inflammable liquids. In some of the regular storage warehouses, where such goods may be sent, cold storage is now used to protect goods against moths; sometimes in such warehouses periodic fumigation with sulphur dioxide or other gases is also practised, which has the additional effect of killing all rodent and other pests that may be present. In modern houses with well-fitted fly-screens clothes moths are, of course, to a large extent, excluded.

Other Household Pests.—Roaches usually accompany filth, though they sometimes are found in cracks under wash boards, in cupboards and in other places where food stuffs are kept. They may usually be exterminated by a vigorous cleaning of cracks and corners and the use of borax or some regular roach powder that is sprinkled about in the places where they are seen; powdered sodium fluoride is said to be effective if used in this way.

Bedbugs, the horror of the good housekeeper, are sometimes a pest in the most carefully kept house in the city, since they apparently come through cracks in the walls from adjoining houses which may not be so carefully looked after. The use of modern iron bedsteads eliminates largely the harboring places for this disgusting pest, and in old fashioned wooden beds they may be killed by spraying the cracks with benzine, or similar fluids, care being taken to avoid all lights while using these liquids. In cases of bad infestations with these or other household insects, fumigation with hydrocyanic acid gas is most effective, but owing to the extreme deadliness of this gas it should only be used according to rigid directions such as are furnished by the U. S. Department of Agriculture.

Fleas occasionally, for some reason, multiply very rapidly and infest dwellings beyond the point of endurance. In single rooms they may sometimes be exterminated by filling the air and covering the floors with pyrethrum insect powder and closing the rooms for some hours; the powder may then be swept up and burnt. In cellars and

places filled with goods, fumigation with hydrocyanic acid or sulphur dioxide may be used.

Red ants sometimes become so extremely numerous as to be exceedingly annoying. In tropical countries these tiny insects are often so numerous that it is necessary to set each leg of the dining room and kitchen tables in a cup or small pan of oil or water to keep the food from being covered with them. In going from Hong Kong to Canton, China, by the night boat, a few years ago, the writer without thinking, put a package of sandwiches on the shelf in a small closet in his stateroom. Early the next morning, six or seven hours later, when he went to get his sandwiches they were an almost *solid mass* of tiny red ants and had to be thrown overboard. In houses the red ants may be fought in the same way as the roaches and fleas, but, owing to their small size and large numbers, their extermination is often a matter of considerable difficulty.

While a large majority of the insects are injurious to man, as has been said, there are numerous forms that are of direct or indirect benefit to him. For example: there are numerous insects that are used as food by the natives of the tropics. The best known of these are the grasshoppers or locusts. "Locusts and wild honey" are mentioned in the Bible as food. In the markets, of Manila, for example, may be seen on the stalls piles of grasshoppers with the appendages removed, ready for cooking. They are cooked in various ways or may even be eaten raw; though the raw locusts are said to be of very disagreeable taste. The cooked ones are said to be really delicious. Nearly every sort of insect is used as food by various savage tribes in various parts of the world, especially the fat, juicy grubs or larvæ of beetles, and lepidoptera. The enormous queen termites, noted above, are also eaten.

Honey-bees.—A more universally esteemed insect diet, especially among civilized peoples, is honey, which has been an article of food from earliest times, the Bible speaking of various lands that "flowed with milk and honey." It was probably the "wild" honey that was first used, just as it is still used occasionally, when a "bee-tree" is discovered; but the keeping of bees in hives so that all the honey made by them might be easily gathered is an ancient custom, probably originating in Southern Asia, or in the East Mediterranean region. The United States is now the greatest producer of honey; in 1900 there were produced 61,000,000 pounds of honey, besides 750,000 pounds of bees-

wax. Many large apiaries are to be seen in California, often on a sunny slope on the edge of a desert. In this state there is a succession of flowers throughout the entire year whereas in colder climates there is a winter season during which no honey is manufactured. The various flowers visited by the honey bees, of which bees there are some 1500 species, often give a characteristic taste to the honey, as happens for example, in some sections, when buckwheat is in bloom and the bees swarm over the fields of white blossoms. It is said that honey is sometimes made poisonous by the bees visiting the flowers of Mountain Laurel.

Honey is not only a delicious food, but is a highly nutritive one; it is also used in medicine. It is frequently adulterated with as much as 75 per cent. glucose, which process, though it is a true adulteration, does not injure the honey as food.

Silk-worms.—The manufacture of silk originated probably in China about 3400 B. C. and is hence one of the oldest of human industries. The raising of silk-worms was introduced into Europe in 552 A. D. and into Virginia about 1600. The production of raw silk has never been profitable in America because of the competition with cheap Italian and Oriental labor for picking the cocoons and reeling the silk.

The introduction of power looms, such as may be seen at Paterson, N. J., a great silk centre, has revolutionized the manufacture of silk goods, but in Canton, China, and doubtless in other places in the Orient, the old-fashioned hand loom, crude and terribly slow, may still be seen.

China and Japan are great producers of raw silk and can probably increase their supply almost indefinitely to keep up with the demand. Japan exports some 11,000,000 pounds per year, 60 per cent. of which comes to the United States. The original source of the raw silk is, of course, the "silk-worm," the larvæ of a moth, of which there are 15 to 20 species; the best known of these silk-worms is *Bombyx mori*, whose habits are, briefly, as follows:

The female lays from 200 to 500 eggs, which hatch, the following spring, into tiny caterpillars; these larvæ grow very rapidly, feeding voraciously on mulberry leaves, until they are about 3 inches long, molting several times; each larva then spins a cocoon of silk threads from 2000 to 3000 feet long, taking about five days for the process. The spinneretts are in the mouth and the silk-secreting glands (like

the web-secreting glands of spiders) extend nearly the entire length of the body. The animal swings its head from side to side, hour after hour, carrying a tiny thread of silk across with each vibration of the head. From this cocoon the adult moth hatches in 15 to 20 days, lays her eggs and dies. The cocoons that are used for silk are heated to kill the inclosed larvæ, for if allowed to hatch they would cut

FIG. 79.—Caterpillar with cocoons of the pupæ of ichneumon fly parasites and (above) one of the adult ichneumon flies. The lines indicate natural dimensions. (From Jordan and Kellogg, *Animal Life*.)

the silk threads in emerging. Sufficient numbers of cocoons are kept alive and allowed to hatch for breeding purposes. The utmost cleanliness and proper temperatures are necessary for the best results. The white mulberry furnishes the best food for the larvæ, though the black mulberry, osage orange and other trees may be used.

Probably all the conditions for the production of raw silk could be as well met in this country as anywhere else except that of handling the cocoons; so long, as this must be done by hand, it is not likely that the industry here can successfully compete with the cheap Oriental labor, as noted above.

Among the beneficial insects, perhaps the most important are those that help us control the destructive ones. These may be divided into the *predacious* forms that attack and devour other insects, and the *parasitic* forms that spend a part of or all their lives on or in the bodies of other insects. Among the predacious forms the ladybird-beetles are perhaps the most important. These little beetles destroy enormous numbers of scale-insects, plant-lice, etc. One of the best examples of their work is seen in the work of the Australian ladybird-beetle, *Novius cardinalis*, that was introduced, some years ago, into California to control the cottony-cushion scale that threatened to destroy the citrus fruit industry in that State. The beetles soon had the scale under control and it is now no longer considered a serious pest. Other species of ladybird-beetles have been successfully introduced into the United States and many of our native species are destructive to certain species of aphids and scale-insects.

Among the parasitic insects are many that like the ichneumon flies, lay their eggs upon or in the bodies of caterpillars; when the eggs hatch the larvæ feed upon and eventually kill the caterpillar, but not until the parasites have reached the pupa stage, ready to transform into the adult insects which repeat the process, Fig. 79. But for the work of these predacious and parasitic insects the control of the destructive forms would be a much more serious problem than it already is.

The value of dragon flies in the destruction of mosquitoes has already been mentioned.

CHAPTER X

PISCES

The animals discussed in this and the following chapters all belong to the phylum Chordata. This rather diverse group contains animals that, at first glance, seem to be very slightly related; but it will be found that they all possess, in a more or less typical condition, at some period in their life-history, three structures or groups of structures that are characteristic of the phylum.

The first of these is the *notochord*, a longitudinal, dorsally placed, cylindrical, skeletal axis, Fig. 80, *nc*, which, in the lower members of the groups, persists throughout life, while in the higher forms it is replaced, in the adult, by a cartilaginous or osseous back-bone.

The second chordate character is the possession, either in the embryonic state or throughout life, of a series of slit-like openings between the pharynx and the exterior; these are the *gill* or *visceral clefts*, Fig. 80, *g*. On the *visceral bars*, the tissue between the clefts, are found in some forms, particularly the fishes, numerous branching, vascular structures, the gills, by which the animal extracts oxygen from the surrounding water.

The third chordate character is a *dorsally placed, hollow, nervous system*, Fig. 80, *s.c*.

The phylum chordata is usually divided into three or four sub-phyla somewhat as follows: 1. **Enteropneusta**, a few worm-like animals of rather doubtful relationships. 2. **Tunicata**, sea-squirts and other jelly-like animals that are more or less common in the sea. 3. **Cephalochorda**, a small group of small, fishlike animals, called lancets, Fig. 80, which exhibit in a very typical way the above-mentioned three chordate characters and are hence extensively used to illustrate a typical chordate. 4. **Vertebrata**, a large and important group, including all of our common domestic animals and others having a vertebral column or back-bone.

Of these four subphyla only the last has any appreciable economic value except as zoological specimens or objects for study, so that the first three need not be considered further.

FIG. 80.—Lateral view of *Amphioxus*, drawn as a semi-transparent object. $\times 2\frac{1}{2}$. (From Galloway, *Textbook of Zoology*, after Perrier *Traité de Zoology*.) a, anus; a.f., atripore; c.f., caudal fin; cir, cirri, on the edge of the vestibule leading to the mouth; d.f., dorsal fin; g, gill or branchial structures, consisting of alternate slits, through which water passes, and the supporting bars, in the walls of which are the blood-vessels; in., intestine, from which as a diverticulum springs the liver; l; m, mouth, surrounded by a fringed velum; my., myotomes or muscle segments; nc., notochord; o, ovaries; r, fin rays; s.c., spinal cord; v.f., ventral fin.

The subphylum vertebrata, the most important of all the animal groups, is variously divided, by different authors, into classes. The older classification was into five classes: I. **Pisces**; II. **Amphibia**; III. **Reptilia**; IV. **Aves**; and V. **Mammalia**. As a matter of convenience this classification will be followed here, though it is now usually customary to substitute for the first class three—the **Cyclostomata**, lampreys and hags; **Elasmobranchii**, sharks, rays, etc.; and **Pisces**, the bony and other more or less typical fishes.

The enormous importance of fishes as food and in other ways will be discussed later; a few of the ways in which the class is injurious to man will first be noted.

Cyclostomes, Fig. 81. This low group of fishes, characterized by the circular, suctorial mouth, the absence of paired fins, the persistent notochord, and other primitive characters, comprises the lampreys (*Petromyzon*) and hags (*Myxine*; *Bdellostoma*) most of which are marine and vary in size from 6 to 36 inches. In olden times lampreys (lamperns) were used as food; now they are seldom if ever eaten in this country and their chief importance is the damage they do to valuable food-fishes. The larger lampreys attach themselves to the bodies of other fish and, by the rasping action of

FIG. 81.—Cyclostomes. Upper figure, Pacific hagfish, *Bdellostoma dombevi*. $\times \frac{1}{3}$. The light apertures along the sides are mucous canals, the dark ones are branchial openings. Middle figure, Atlantic hagfish, *Myxine glutinosa*. $\times \frac{1}{2}$. The dots along the side are mucous pits; the left common branchial aperture is at *. Lower figure, sea lamprey, *Petromyzon marinus*. $\times \frac{1}{6}$.

the horny teeth that cover the tongue and buccal cavity, they cut through the body wall and suck out the blood and soft parts until the victim dies; then they seek another host. Fish are sometimes found with one or more of these holes in the body wall, through which a loop of the intestine may protrude. In Cayuga Lake, New York, some years ago, serious damage was done the food-fishes by the large lake lampreys that were abundant there, so that a systematic warfare was carried on to exterminate the pests.

The hags are parasitic in the same way upon marine fishes, except that they enter the body-cavity of the host through the hole they cut, and emerge again upon the death of the victim. Considerable damage is thus done the fishing industry in some regions.

Elasmobranchs.—In this group are found the sharks and rays, which include the largest of all the fishes. Their value as food will be noted below; their negative importance will here be briefly described. In this connection the so-called man-eating sharks will at once come to mind. To what extent these monsters are dangerous to man is difficult to determine. There were fish specialists, a few years ago, who expressed great doubt as to whether man was *ever* attacked by any species of sharks, and it is probable that the majority of sharks are quite harmless, so far as attacking man is concerned. It is difficult to believe, however, that all the stories that are told in the tropics about man-eating sharks are fabrications, and it will be remembered that during the summer of 1916 there were several apparently authentic cases of loss of human life by sharks along the Atlantic coast of the United States; for example; the Baltimore Sun of July 7, 1916, had these headlines: "Shark Kills Bather. Bites off both Legs of Bellboy at Springlake, N. J.—Second Case in a Week."

While sharks of various species are common in the North Atlantic these visits from the man-eaters were very unusual and zoologists had various theories to explain the strange phenomenon.

The shark that is usually called the "man-eater" is the Great White Shark, genus *Carcharodon*; this monster, according to Jordan, reaches a length of 25-feet; Günther says it is sometimes 40 feet long and has been known to cut the body of a man in two at one bite. It is an inhabitant of tropical and subtropical seas, where it is much feared in some regions, by the water-loving natives. The other sharks, though they may reach a large size, are probably, as has been said, quite harm-

less to man, but are often injurious in other ways. For example, the small, dogfish sharks, *Mustelus* and *Squalus*, Fig. 82, are in many places very destructive to lobsters, crabs and various food-fishes, and to squid that are used for bait; they also seriously damage nets and other fishing gear. It is estimated that these dogfish cause a damage of at least \$400,000 a year to the fisheries of Massachusetts. Other larger sharks though less common are often very destructive in the same way, as are the larger skates. It is not uncommon, in pulling a seine, to enclose a 6- or 8-foot shark that, in dashing to liberty, tears a great hole in the net that not only allows other fish to escape, but may take hours to repair. On one small sandy beach, of a few hundred

FIG. 82.—Dog-fish, *Squalus acanthias*. $\times \frac{1}{10}$.

yards length, on the coast of California, I once counted eight sharks of an average length of about 5 feet that had been drawn out of the sea in one morning by a group of fishermen who were seining there. On the same beach were often seen a considerable number of large rays that had been caught in the same way, and each of them had probably caused some damage to the nets. It is no wonder that the fishermen despise these elasmobranchs.

There are certain rays, known as sting-rays or "stingarees," in which the tail is armed with one or more spines, barbed on the sides and sometimes, in large species, 8 or 9 inches long. These rays are more common in warmer waters and are much dreaded by fishermen as they can, with a sudden swing of the tail, inflict an ugly wound that may be excruciatingly painful, or even, according to Günther, cause death. The poison that enters the wound made by the spine may be merely in the mucus of the body or it may be secreted by a definite gland at the base of the grooved or hollow spine.

Another formidable group of rays are the *torpedoes* or *electric rays*, Fig. 83. There are several species of the genus *Torpedo*, some of them 2 or 3 feet across; one of these large animals may, by a single discharge, disable an adult man, according to Günther. The electricity is generated in a pair of flat, curiously formed organs, lying on either side of the head. The electric organs are thoroughly enervated

and are under the voluntary control of the ray. There are also electric eels that are capable of giving a powerful shock.

Let us now notice several ways in which the elasmobranchs are of *positive* economic importance. In many countries, especially of the orient, the smaller sharks and some of the skates are used as food, either salted, dried or fresh. Some negro tribes are said to allow the flesh to decay before eating it. In America a senseless prejudice exists against eating sharks, but dogfish are now being canned and sold under a trade name and are a very agreeable addition to our list of food-fishes. In the markets of China small sharks are exhibited for sale the same as the ordinary food-fishes. Until the demand

FIG. 83.—The torpedo or electric ray, *Torpedo occidentalis*. $\times \frac{1}{4}$. (From Dean, *Fishes, Living and Fossil*.)

for this new food is much greater the excess of dogfish and other small sharks, captured by fishermen, can be used in making fertilizer. There is a limited demand for the smaller sharks by colleges and universities for dissection purposes by classes in zoology.

In China and India the fins of sharks and rays are extensively used for the production of gelatine and their collection is quite an important industry.

Some of the larger sharks are useful sources of oil; a basking shark

may produce over a ton of this substance, which is obtained mainly from the liver. This huge fish may attain a length of over 30 feet.

The skin of certain sharks and skates, armed as it is with sharply pointed, tooth-like scales, is sometimes used as a polisher of wood and other materials and is known as *shagreen*.

Pisces.—Under this head will be noted some of the more important of the so-called *teleost* or *bony fishes*; the Dipnoans or lung-fish, which also belong in this group, tho extremely interesting zoologically, are not of sufficient economic importance to warrant discussion here.

It is, of course, as food for man that these fish are chiefly important though there are some other ways in which they are economically important. For example: the swim-bladder of the sturgeon and some other fish is used to make isinglass, fish-glue, mock pearls, etc.; the menhaden, a coarse kind of herring, is caught in seines by the ton and made into oil and fertilizer, several dozen fishing steamers being engaged along our coasts in catching them and conveying them to factories on shore; cod-liver oil is made from the livers of various species of cod-fish.

The importance of fish as a food product is best appreciated by visiting a large fishery along the North Atlantic coast or on one of the great rivers of either coast. Along both coasts of the North American continents and in the Great Lakes there are thousands of small vessels constantly engaged in the catching of fish. On the Columbia River are the huge salmon canneries and on the rivers of the east, are the fisheries for herring, shad, etc. Tens, possibly hundreds, of millions of dollars a year result from the fisheries of the United States.

While most species of fish are suitable for food there are some that are poisonous either at all times or at certain seasons of the year. L. L. Mowbray (1116) says: "Much has been said and written about the poisonous fishes of tropical and sub-tropical seas. It is a known fact that among people eating the same species and at the same time, even caught in the same locality, some have been poisoned, while others have not. Among fishes eaten by man, the species considered most likely to be dangerous as food during the season from May to October, are the barracuda, two species of kingfish, three species of jack, red rockfish and tiger rockfish." . . . "All these fishes are carnivorous, preying upon various species of fishes and invertebrates. There is no evidence whatever that they feed at any season upon forms which would

render their flesh unwholesome." According to Dr. Geogaghan (116) once medical officer of the Turk Islands there are two forms of disease produced by these fish: one, like ordinary ptomaine poisoning, coming on 10 to 20 hours after eating the fish, acute but yielding quickly to treatment; the other producing slow dull pains, especially of the joints, coming on from 2 to 6 days after eating the fish and lasting many months. The same fish that cause these diseases in the Turk Islands and Bahamas are eaten at Key West and Bermuda where the poisoning is unknown. The reason for this Mowbray explains as follows:

"After observing the conditions and manner in which the fish are handled, I have reached the conclusion that the reason they are poisonous, in one region and not in another, is that in Bermuda and Key West almost all fishing boats have live-wells, and therefore usually bring their fish to market alive, while in the Turk Islands and the Bahamas the fish are killed and allowed to remain in the sun until the shore is reached, sometimes 5 or 6 hours after they are caught. All of the fishes considered poisonous are of soft flesh and rich in gastric juices, and are therefore the most likely to decay quickly; and, when eaten in a partially decayed condition, cause *ptomaine poisoning*. Naturally, some are more poisonous than others. Those caught in the morning are exposed to the sun rays much longer, and are therefore much more decomposed."

It would seem from this that possibly the poisonous character of fishes is largely a matter of their being more or less decomposed, though it is thought by some to be due to the character of the food eaten at different seasons.

The most important of the world's food-fishes are said by some to be the herrings. This family (Clupeidæ) includes considerably over 100 species and is probably more numerous in individuals than any other family of fishes.

The *common herring* (*Clupea harengus*) is one of the most important of all food fishes; it is caught in nets in enormous numbers along the Atlantic coasts of both North America and Europe. For example at Port Deposit, Maryland, a fishing station on the Susquehanna River, these fish are caught in huge seines, hundreds of feet long, which are hauled in by an engine or by horse-power upon a floating dock; 100,000 fish may be brought in at one time in this way. They are cleaned, salted and packed in barrels on the spot so that they have no opportunity to decay in the least. It has been estimated that at least 10,000,000,000 herring are caught annually by British and American

fishermen. There has been much uncertainty as to the habits of the true or sea-herring. It is supposed that there are numerous races, each of which swims in a separate school, sometimes in such enormous numbers that they form a closely crowded mass of from 5 to 20 square miles. These schools migrate from the deep sea toward the coasts where they spawn. The river-herrings or alewives are the ones that were mentioned above as being caught in large numbers as they ascend the rivers of the Atlantic coast to spawn, they are largely smoked and salted.

The *shad*, one of the finest of all food fishes, belongs to the herring family, and, like it, is caught in the rivers of the Atlantic seaboard, which it ascends for the purpose of spawning. Being a large, finely flavored fish it is usually eaten fresh, while the common herring is largely salted or smoked. The shad was successfully introduced into California, years ago, and is now abundant from Monterey Bay to Alaska.

In spite of the fact that it is very prolific, an average female producing from 30,000 to 100,000 eggs, while many individuals produce several times that many, the shad has been largely reduced in numbers, with a corresponding rise in price. But for the work of the United States Bureau of Fisheries, to be discussed later, this delicious fish would probably have been practically exterminated. In 1900 this Bureau hatched and distributed 241,056,000 shad fry.

Although, as noted above, shad produce eggs in enormous numbers, they are deposited more or less at random in the fresh water of the rivers, no nest is built and the percentage of loss of eggs is very high; added to this is the destruction by other fish and by man (who always catches them on the way to the breeding grounds), so that it is no wonder the industry was threatened with extinction.

After spawning, the adults begin to feed again, and move toward the sea. The young shad remain in the rivers until about November of the first season when they are about 3 inches long; they remain in the sea for 3 or 4 years, till sexually mature, when the female may weigh from 3 to 6 pounds or more. The shoreward migration of shad depends upon the temperature of the water; it begins along the southern coasts and gradually extends northward as far as the St. Lawrence River.

Another important member of the herring family is the *sardine*, the tiny fish characteristic of the Mediterranean Sea and presumably

named from the Island of Sardinia. The sardine is the most important fish of France. There are about 100 canneries for sardines, some of which have an annual output of 5,000,000 cans. There are various small species of the family Clupeidæ that are known as sardines, the typical French species being the young pilchard, *C. pilchardus*.

On the coast of California is a small fish, somewhat larger than the French sardine, that is canned in the same way in which the Mediterranean species is preserved, it is a true sardine, *C. caeruleus*. Eastport, Me., is the chief centre for sardines in the United States. The annual output of the canneries of Maine is about 550,000 cases, valued at about \$2,000,000.

The *cod-fish* (*Gadus morrhua*) is one of the most important of all the food fishes; it reaches a length of 3 or 4 feet and is characteristic of colder seas. As long ago as 1415 English fishermen sought the cod-fish on the coast of Iceland and since the sixteenth century they have been coming to the banks of Newfoundland. It is said that more than half the human population of Newfoundland get a living through the cod fisheries. It is also an important business in the North Atlantic region of the United States. Unlike the preceding the cod is caught with set-lines and hand-lines, rather than with seines, tho trap-nets are also used. When brought to shore the fish are largely split open, rubbed with common salt, and then thoroughly dried by spreading them on platforms of boughs, known as "flakes," in the sun. In good weather the fish will be cured in a week and is then hard and stiff. Each fish is turned over at least once a day so that both sides may be cured.

The cod spawns at moderate depths and the eggs rise to the surface of the sea, where they remain till hatched. An average sized cod is said to produce from 2,000,000 to 4,000,000 eggs a year.

The *haddock* is another well-known food fish belonging to the cod-fish family.

The *salmon* family (Salmonidæ) includes many of our finest, largest and gamiest food fishes, since besides the salmon proper, whose very name (from *sa'io*, to leap) indicates its active vigorous nature, the family includes various species of trout and white fish. While the trout are more popularly known to sportsmen and others, the great *Quinnat* or *King Salmon* of the Columbia River is economically, the most important member of the family, if not of all the fishes of the country. This magnificent fish, sometimes weighing 75 pounds, is

caught as it enters the Columbia and other rivers of the Pacific coast by various mechanical contrivances; it is caught by the ton and is largely canned, on the spot. In 1908 the salmon fisheries were estimated at \$10,500,000. This wholesale destruction of these animals on the way to their breeding grounds would doubtless long ago have seriously impaired the business but for the work of the U. S. Bureau of Fisheries. The remarkable life of this fish is too well known to need more than a mention here—how it leaves the sea as sexual maturity approaches, ascends the rivers, often for hundreds of miles, swimming rapids, jumping water-falls and overcoming astonishing obstacles until it reaches the quiet protected headwaters where the eggs may be deposited in safety; how the adults, wasted and torn by their long foodless journey, die without ever regaining their native ocean; how the eggs hatch into the tiny fish that gradually work their way down-stream, feeding as they go, until they reach the ocean as vigorous young salmon, able to dart about and escape the many enemies of the deep; and how these young salmon remain in the sea until they, in turn, have reached sexual maturity, when some mysterious impulse impels *them* to leave the ocean and ascend the rivers to certain death, that their kind may be perpetuated. It is a wonderful illustration of the way nature often sacrifices the individual for the good of the race.

Swordfishes, Fig. 84, are an interesting, though not a very important group. They are the largest of the teleost fishes sometimes reaching a length of 12 or 15 feet. The flat, blade-like snout which gives them their name is a very effective weapon, with which they are said to attack and kill whales; and it has been frequently reported that they have punctured the bottoms of small wooden boats, possibly mistaking them for their cetacean enemies, though why they should attack a whale at all is not clear. Swordfish "steaks" are a common article of diet in New England and elsewhere, and while perhaps not so delicate as some of the smaller fish, they are excellent food. A common method of capture of these large fish, which can cut their way out of an ordinary net, is to harpoon them from a small platform fixed on the bowsprit of a small sailing or power boat; it is a form of sport requiring both patience and great skill.

The *sturgeons*, Fig. 85, are the largest of the freshwater fishes of the northern hemisphere where they occur. They may reach a length of 10 feet and are covered with hard, bony plates. Their flesh is used as

food and their eggs, which are small and produced in enormous numbers (one female, it is estimated, may produce 3,000,000 in one season) are made, especially in Russia, into Caviare. Besides this, from their air-bladder is made isinglass, as was noted above.

Besides these few, hundreds of species of useful fishes might be mentioned, as there are probably but few that are not used as food by somebody, somewhere.

FIG. 84.—Sword-fish (*Tetrapturus*), yellow-fin tuna, and yellow tail, caught with rod and reel at Santa Catalina Island. (From Dougherty, *Economic Zoology*, after *Bulletin of B. of F.*, vol. xxviii, 1908.)

Fish-culture.—The possibilities of fish-culture have been long recognized. This science was practised in early ages by the Chinese and later by the Romans. It was introduced into the United States about 1865; and in 1871 the federal government established the United States Fish Commission, now known as the Bureau of Fisheries. While the chief work of this Bureau is, perhaps, the artificial propagation of food

fishes, it also looks after the lobster, shell-fish, sponge and other industries dealing with aquatic life. It also controls laboratories for research at Woods Hole, Mass., Beaufort, N. C., and elsewhere. It

FIG. 85.—The Russian sturgeon, *Acipenser huss.* $\times \frac{1}{20}$. (From Jordan and Heath, *Animal Forms*, after Brehm.)

owns several vessels equipped for deep-sea dredging and other lines of marine investigation; also several railway cars fitted with tanks, aerating pumps, living quarters for attendants, etc., which are used in

transporting young fish from place to place. In 1901 the Bureau planted somewhat over 1,164,000,000 fish in waters of the United States. About $\frac{1}{4}$ of these were whitefish and $\frac{1}{5}$ were shad.

Many of the individual States have their own fish commissions with numerous hatcheries conveniently located. In Europe there are, or were before the war, more than 400 fish hatcheries, more than half of which were operated profitably by private individuals; it is claimed that a profit of 1500 per cent. had been made in this work.

The primary object of fish-culture is to increase the proportion of eggs that hatch and to protect the embryos and young fish until they have safely passed the perils of early life and are able to take care of themselves. As in most animals the young fish are very helpless and, under natural conditions, easily fall prey to various enemies or are destroyed by unsuitable environmental conditions; the result is that the struggle for existence is extremely severe and the mortality enormous. Under the artificial conditions of the hatchery natural enemies of the young fish are excluded, and the environment is made as ideal as possible without making it too unnatural. In nature the loss begins with fertilization. Where the eggs are fertilized in the open water of a pond or swiftly running stream it is obvious that many may easily escape coming in contact with spermatozoa; these of course will die and be lost. This loss is almost entirely avoided in the hatchery by the process of "stripping" and artificially mixing the eggs and sperm. In this process the male and female fish are carefully caught, at the time of sexual maturity, and stripped of their eggs and spermatozoa (roe and milt) by holding over a vessel and gently pressing out the roe or milt. Both fish must be ripe or fertilization will not take place. If ripe the belly of the fish feels soft and flabby, and if it be held up by the head the eggs will settle down toward the vent and almost run out without outside pressure. If not ripe the belly of the fish feels firm and considerable pressure must be exerted to strip out the eggs.

The eggs are first stripped into a perfectly clean vessel with a small amount or even no water; then the milt is stripped into the same vessels and the mass gently shaken to insure thorough mixing of eggs and sperm. Fertilization takes place at once; after allowing the mass to stand for 15-20 minutes it is rinsed in clean water and transferred to the hatching trays. By this process from 90 per cent. to 100 per cent. of the eggs will be fertilized and an enormous saving over the natural method will result.

While in the hatching trays the eggs are examined frequently, and are sometimes stirred and rolled over with feathers; sometimes they are stirred by raising and lowering the trays in the water; and any eggs that escaped fertilization, or for any other reason have died, are carefully removed before they have time to mold or decay and infect the good eggs. A dead egg has a sort of opaque appearance that, with a little experience, is easily recognized. The hatching trays are of various types, a common form being a box about 15 X 24 inches and 6 inches deep made of galvanized wire netting. These trays, containing thousands of eggs, are usually placed in narrow, wooden troughs with a series of transverse partitions so arranged that the stream of water that passes through them is forced upward through the eggs in the tray and keeps them thoroughly mixed and aerated. The arrangement of trays, etc., varies at different hatcheries and with varying conditions.

In a month or more, varying with the temperature of the water and other conditions the eggs hatch and the young fish, with the huge yolk sack attached, wriggle out of the trays and are taken care of until the yolk is absorbed and the fish are active and able to take care of themselves if liberated into the waters of a suitable stream. While the yolk is still present the fish will not feed, but if they are kept longer they must be fed at frequent intervals on finely minced liver or other meat, great care being taken to prevent fouling of the water by uneaten scraps of meat.

One of the primary factors in handling the eggs and young fish is cleanliness. Unless the water is of exceptional purity it must be led into settling tanks where the heavier sediment settles to the bottom and then it may be necessary to strain it through cloth to remove the finest particles of foreign matter that in the open streams, settles over the eggs and causes high mortality. Another factor is a free circulation of water in sufficient quantity to keep the eggs in motion and to keep them well aerated. It is often important that the temperature of the water be low during the season when hatching is in progress.

When the young fish or "fry" have reached a proper size it is often necessary to transport them long distances to the place where they are to be liberated. For this purpose, as noted above, the Bureau of Fisheries employs several cars with tanks and aerating devices. The vessels most commonly used for handling the fry are the ordinary, large milk cans, holding about 15 gallons. The water in these cans must

be kept cool, which in summer may necessitate the use of ice, and it must be either aerated or frequently changed. It is sometimes possible to keep it sufficiently aerated by dipping it out with a cup and pouring it back from some height.

In some cases it is desired to ship the eggs to a distant point, where their further development will take place. This is done in various ways. In some instances, light wooden boxes are used and the eggs are packed as follows: a layer of damp material, preferably sphagnum moss, is placed in the bottom; over this a sheet of wet cheese cloth is spread upon which a layer of eggs is laid; over the eggs another sheet of cloth and another layer of damp moss are placed and this is repeated until a dozen or more layers are present, perhaps with a horizontal partition or two of wood to prevent too great pressure on the bottom eggs. This box is now packed in the centre of a larger box with dry moss or other shock-absorbing material and may be sent on a journey of several days' duration. In warm weather various methods are used to keep the eggs cool.

The above is a brief account of the general methods of fish culture; the method varies with the different species of fish, with the locality, and with other varying conditions.

There are many farms, remote from the coasts or from large bodies of water, where fresh fish are almost an impossible luxury. In many cases there are, or could be constructed, on these farms, large ponds, often used for the gathering of ice, where fish in sufficient numbers to supply the family could be raised at a nominal cost. If the pond be surrounded by a rank growth of vegetation it will support a considerable number of fish; if the pond be new or have a more artificial environment the fish will probably have to be fed. The kind of fish best suited to the pond will have to be determined by the local conditions. For example if the water be sluggish carp or cat-fish will have to be raised; if there be a fairly rapid circulation, changing the entire body of water every week, bass or perch may be kept; if the circulation be sufficient to change the water every day or two trout may be raised. The pond may be stocked with a few adults or by planting eggs or *fry*, which may probably, in most cases, be obtained from the nearest State hatchery or from the U. S. Bureau of Fisheries. Various bulletins upon the subject have been published that give specific directions.

CHAPTER XI

AMPHIBIA (BATRACHIA)

As the name indicates this is a class of animals that have two modes of life, aquatic and terrestrial. The eggs are usually laid in water and hatch into fish-like tadpoles that may later give up their aquatic habits and live on land. Nearly all of them breathe by gills, in the larval condition, and many of them retain these gills through life, though lungs are usually present in the adult, sometimes being present in the same animal with the gills. The Amphibia, though so fish-like in many cases, are distinguished from the Pisces, by having pentadactyle limbs, usually without claws, in place of paired fins (where paired appendages are present at all) and by the absence of fin-rays in the median fins, where these organs are present. The skin is glandular and a bony dermal exoskeleton is sometimes present. There are also numerous characteristics of internal structures that need not be noted here.

The Amphibia are interesting as illustrating the transition from water-breathing to air-breathing forms. The lower species retain their gills throughout life, while the higher forms lose their larval gills and breathe entirely by means of their lungs and skin. This metamorphosis from the tadpole to the adult may take place in a few months or it may take a much longer time. Coincident with the disappearance of the gills and the development of the lungs the limbs usually make their appearance, the tail is absorbed, and other marked external and internal changes take place, Fig. 86.

As noted later, the tailed amphibia are very commonly confused with certain reptiles and called lizards; but they may usually at once be distinguished from the latter by the absence of scales and claws and by differences of habits, the former being usually found in dark, moist places while the latter prefer dry, sunny localities.

There are fewer known species of living Amphibia than of any of the vertebrate classes, the estimates varying from about 1100 to 2200. With the extinct forms we are not especially concerned since they can

scarcely be said to have any economic value, except, perhaps, in the determination of geological horizons. As in other groups the classification of the Amphibia varies with different authors; the extinct forms are usually placed in two or three orders, the living forms in the following three orders: 1. *Apoda* or *Gymnophiona* are legless, snake-like or worm-like forms found chiefly in the tropical and subtropical countries; 2.

FIG. 86.—Metamorphosis of the frog. Tadpoles in different stages of development, from those just hatched (1) till the adult form is reached (8). 1-3, about life size; 2a, enlarged; 4-8, somewhat reduced. (From Hegner, *College Zoology*, after Mivart.)

Caudata or *Urodela* are the tailed Amphibia, such as mud-puppies, salamanders, etc.; 3. *Salientia* or *Anura* are the tailless forms, the frogs and toads. Of these three orders the last is by far the largest and the first the smallest. In cold regions the amphibia hibernate through the severe winter weather by burying themselves in the ground or in the mud and leaves at the bottom of ponds and streams. Being inoffensive

creatures they depend for protection upon their activity, their protective coloration and in some cases, upon poison glands in the skin. Many of them have considerable power of regenerating lost parts.

FIG. 87.—Mud puppy or water dog. *Necturus maculatus*. $\times \frac{1}{3}$.

FIG. 88.—Hellbender or "Alligator," *Cryptobranchus alleganiensis*. $\times \frac{1}{6}$.

Although not one of the more important groups economically, practically all of the Amphibia are of some value to man, and few if any are more injurious than beneficial.

Of the *Apoda* little need be said; although they feed on worms and insect larvæ, they are not numerous enough to be of great importance.

The *Caudata* which are represented by several more or less popularly known species are probably of considerable value as destroyers of insects. Even the smaller salamanders, Fig. 89, that are more numerous than is commonly supposed because they are largely nocturnal and secretive in habits, doubtless destroy many insects, both adult and larval. Some of the larger forms like the common mud-puppy (*Necturus*), Fig. 87, and the hellbender (*Cryptobranchus*), Fig. 88, are also

FIG. 89.—Spotted salamander, *Amblystoma punctatum*. $\times \frac{3}{4}$. (From Surface, *First Report on the Economic Features of the Amphibians of Pennsylvania*.)

useful as scavengers in our streams, though they sometimes are a nuisance to fishermen by taking their bait. Although the writer has made but few experiments there seems to be no reason why these larger salamanders should not be used as food. Their flesh looks as attractive as that of the frog and in a two-foot giant salamander (*Cryptobranchus*) there is a considerable mass of flesh, especially in the tail, in a full grown *Necturus* also there is a considerable quantity of flesh which is very palatable.

The *Anura* are by far the most important, economically, of the Amphibia. Of the various families of this order three will be noted:

the Hylidæ or treefrogs, the Ranidæ or true frogs and the Bufonidæ or toads.

The *Hylidæ*, Fig. 90, are usually small forms; they are arboreal in habits, as the name indicates, and as an aid in climbing have adhesive disks at the ends of their fingers and toes. They have remarkable vocal powers, due partly to the presence of a large vocal sac. Of the nearly 200 species, more than a dozen are found in North Am-

FIG. 90.—Tree frog, sp. $\times 1$. Note discs on toes.

erica. Though doubtless of less importance than the other Anura, these small frogs probably destroy large numbers of harmful insects.

The *Ranidæ*, of which there are more than 250 species, more than a dozen of which occur in the United States, are useful as destroyers of insects, as subjects for dissection and experimental work, and especially as an article of diet.

Almost any of the true frogs may be used as food, though many people think that only the bullfrogs are edible. A similar mistaken idea pre-

vails in the belief that only the hind legs can be eaten, as a matter of fact many persons, after skinning, cutting off the head and eviscerating, fry the entire body, perhaps in egg and bread-crumbs, perhaps without. The main muscles, of course, are those of the hind legs, but there is no sense in wasting all the rest of the body.

Of our native frogs the common bullfrog, *Rana catesbiana*, Fig. 91, is the largest and most generally known as an article of diet; it may reach a length of 8 inches and its deep, bull-like roar is a familiar

FIG. 91.—Common bullfrog, *Rana catesbiana*; male. (After Chamberlain, *Edible Frogs of the United States*.)

sound to those living in the eastern half of the North American continent. In the adult condition its larger size and massive, clumsy shape will distinguish it, ordinarily, from the other common species, as will the presence of a fold of skin that arises back of the eye, passes over the tympanum, past the insertion of the foreleg, to disappear on the chest; the complete webbing of the hind toes and the absence of the dorsal folds of skin will also serve to distinguish it. The color is quite variable but there is apt to be a considerable amount of deep green above and of yellow beneath.

There are two species of western frogs that are found along the coastal States; they are not so well known as the common bullfrog.

A frog somewhat similar to the bullfrog, both in appearance and in habits, is the green or spring frog, *R. clamata*, Fig. 93; it is much smaller in size, however, the adult measuring only 3 inches. Instead of the deep bellowing it has a note that may be represented by the words, "chock, chock, chock," and an occasional single note "chung." It is, in many places the first species heard in the spring. It is more or less solitary in habits and seldom leaves the water. Like the preceding species it passes the first winter in the tadpole stage.

The most widely distributed of our frogs is the common frog, leopard frog, spring frog or shad frog, *R. virescens*, Fig. 92. It is found over practically the entire continent east of the Sierra Nevada Mountains. It reaches a length of $3\frac{1}{2}$ inches and is distinctly marked

FIG. 92.—Spring or leopard frog, *Rana virescens*. (After Chamberlain, *Edible Frogs of the United States*.)

on the back and sides and legs with dark, rectangular blotches bordered with white or yellow. A glandular fold runs from the eye, along the dorsal part of the side to the posterior part of the body.

The pickerel, marsh, or tiger frog, *R. palustris*, closely resembles the leopard frog from which it may be distinguished by the bright yellow on the legs. It is the most active of the frogs and is seldom eaten. Though preferring cold streams, it is often found in grass; it is rather solitary in habits.

The flesh of frogs is best in the fall and winter. Later in the season, after prolonged hibernation, the body is more or less emaciated.

Frogs are collected for the market in large numbers in California, Missouri, Arkansas, Indiana, Ohio, Maryland, Virginia and New York,

especially in the last, also in Ontario and other parts of Canada. They are sold alive and by the pound, dressed, the price varying with the locality, season and other conditions.

Frogs are collected in various ways—a hook and line, baited with a piece of red cloth is sometimes dangled in front of the frog who seizes the moving cloth and is thus hooked; small bore fire arms and various spears are also used, sometimes at night with a bright light to dazzle the eyes of the frogs; sometimes they are dug out of the mud where they are hibernating.

Unrestricted hunting has, in some localities, nearly exterminated the frogs and has brought up the subject of their artificial propagation. Without sufficient knowledge of the breeding habits of frogs it would seem that, with the high market values usually prevailing, it should be an easy matter to make large profits by raising them for market. Part of the process is quite easily handled, but, as we shall see, there is one peculiarity in the habits of frogs that is difficult to meet. Everyone is familiar with the masses of frog eggs that are seen in small ponds and sluggish streams in the early spring; these may be collected in almost unlimited numbers. In a few days or weeks, depending upon the temperature of the water, these eggs hatch into tiny tadpoles that soon begin to feed voraciously upon any kind of organic material that may be available and to grow rapidly. During the tadpole stage there are many enemies such as birds, snakes, turtles, crawfish and adult frogs, that destroy these larvæ in large numbers so that the first problem of the frog culturist is to protect in some way the eggs and tadpoles. This may be done by collecting the eggs and allowing them to hatch and develop in artificial ponds or tanks where the tadpoles may be fed and protected, or better, perhaps by screening small natural ponds with wire netting to keep out the above-mentioned enemies and stocking these ponds with a number of adult frogs, males and females, to lay the eggs. In this way tadpoles without number may be raised, but the main difficulty mentioned above, arises when the tadpoles change to frogs, which happens in from two months to two years. It is essential that when this transformation takes place that the young frogs or old tadpoles, whichever they may be called, Fig. 86, have a sloping shore where they may crawl out on the bank, otherwise the metamorphosis is indefinitely postponed; tadpoles have been kept in aquaria for several years without transformation because of lack of a place for them to leave

the water. The difficulty that arises is that while the tadpole would eat anything the frog will eat nothing that is not moving. A dead insect on the ground will remain untouched; one that is drifting along on the surface of the pond will be seized and eaten. Here, then, is the stumbling block to the frog culturist, to supply living food to the numberless young frogs that he has obtained so easily. Various methods have been tried. For example meat was strewn on the shore and allowed to decay with the idea that it would attract flies and other insects for the frogs, but the decaying meat is apt to foul the water and kill the young

FIG. 93.—Green or spring frog, *Rana clamata*. (After Chamberlain, *Edible Frogs of the United States*.)

frogs and tadpoles. The only practicable method seems to be to use natural ponds whose banks are covered with a rank growth of vegetation that will supply the necessary insects. Such a pond should be partly shaded and, of course, must not dry up as summer progresses.

In this way, by aiding nature somewhat, frogs are successfully raised at a number of places; for example in Ontario such a farm has been in operation for 25 years, producing in one year as much as 5000 pounds of dressed legs and 7000 living frogs.

It usually requires three or four years for frogs to reach maturity and it is generally supposed that they may live for 15 or 20 years.

One danger to eggs and tadpoles that cannot well be eliminated by frog culture is from late cold spells that may freeze the shallow pools and kill large numbers of the inhabitants.

The *Bufonidæ* include over a hundred species of toads belonging chiefly to the genus *Bufo*; over a dozen representatives of this genus have been found in North America.

The common toad of the eastern United States, *Bufo lentiginosus Americanus*, Fig. 94, is familiar to all as the clumsy, warty animal that,

FIG. 94.—The American toad, *Bufo lentiginosus americanus*. $\times \frac{3}{4}$.

after hiding in some dark nook all day, hops out, toward dusk, to seek his food during the night. Being an ugly animal the toad, in olden times was considered highly venomous, as noted by Shakespeare and other more ancient writers, and a remnant of these superstitions is seen even now in the very common and entirely erroneous belief that warts may be caused by handling toads. As a matter of fact, however, the glandular warts so characteristic of the toad do secrete a substance that protects them quite largely, from being eaten as are the other members of the Urodila, though the flesh is said not to differ appreciably in taste from that of the *Ranidæ*.

While the adult toad is primarily a land animal and hibernates in some cavity under ground, usually in groups, it seeks the pools in early spring to spawn as do the rest of its class, laying the eggs in long, easily recognized strings, instead of in masses; 1200-1500 may be laid by a single female. During the breeding season the toad's call may be heard as a pleasant, tremulous trill, lasting usually about 5 or 10 seconds. The development is about the same as that of the Ranidæ. It is said that sexual maturity is not reached until the fourth year. Much has been conjectured and written about the age to which toads may live but nothing very definite seems to be known; it seems likely that they may live for 20 years or more. Of the familiar stories of toads being found in the centre of rocks little need be said; a little common sense will show the absurdity of supposing an animal could remain alive during the thousands or millions of years that must have elapsed since such rocks were laid down as sand or mud. A number of actual experiments have been tried to test this oft-repeated tale; toads were buried in cavities in the centre of plaster-of-Paris blocks and in sealed cavities in rocks of various sorts; none of the toads lived more than two years, and while it is surprising to find any animal living so long without food and water, two years is an infinitesimal time compared to the age of rocks. The numerous recorded cases of these rock-encased toads are doubtless to be explained as errors of observation or as pure fabrications.

As has been said the toad feeds largely at night, in towns often collecting under the electric lights and eating the insects that fall to the ground in large numbers at such places. Kirkland, who has carefully studied the feeding habits of the common toad, makes some interesting observations. He says the toad's food is about 88 per cent. insects, and 16 per cent. of these are cutworms; counting these destructive cutworms alone he estimates the annual saving to the farmer by each toad as nearly 20 dollars. He finds that the toad eats four stomach-fulls every 24 hours; in three months this will amount to about 10,000 insects, a majority of which are injurious; slugs, myriapods, etc., are also eaten; in fact any moving animal of suitable size, even stinging bees, are snapped up by the lightning-quick, sticky tongue. By confining a toad in an open box with syrup or other sweet substance to attract insects its methods of feeding may be studied in an interesting way.

By watching the live toads and by examination of the stomach contents of others, Kirkland collected valuable data in regard to their food at different seasons and under different conditions. For example during a pest of army worms he found in one toad's stomach 55 of the worms; at another time he found 65 larvæ of the gypsy moth in one stomach; and in another toad were found 37 tent caterpillars.

These and many other figures might be given to show that as an insect destroyer the toad probably has few superiors and that it is, perhaps, quite as valuable as the average bird and should be equally protected by law. They are useful not only in gardens but may be kept in greenhouses. In a certain greenhouse in Massachusetts a valuable collection of orchids was saved by the introduction of a number of toads. They should be collected and brought into gardens, as is done in France, and a number of boards or stone shelters provided for them to creep under and escape the heat of the sun. Probably if the garden were provided with a small pond of running water they would breed there and greatly increase their numbers. They frequently take up more or less permanent summer quarters under porches and other places to which they return every morning after the night's hunt.

Their chief enemies are hawks, crows, and snakes and from these they could be protected, more or less, in gardens. Chickens and ducks also are destructive to the young toads; and the ubiquitous small boy who, unless otherwise educated, is an enemy to all living things, is also prone to kill toads of all ages. Fortunately the toad is not used as an article of human food, so that the pot-hunter, the worst of all enemies of the lower animals, does not trouble him.

It will be seen, then, that practically all of the Amphibia are of some value to man and that few if any of them are harmful in any way.

CHAPTER XII

REPTILIA

Reptilia are cold-blooded vertebrates with an epidermal skeleton of scales, and often with an armor of bony dermal plates. They never breathe by gills and do not have the tadpole stage seen in the Amphibia. Many of them lay eggs of a large relative size, inclosed in a leathery or a calcareous shell. The centra of the vertebræ have spheroidal articular surfaces. There is one occipital condyle and the mandibles usually, and other bones frequently, bear teeth. The ventricles of the heart are usually incompletely separated and there are always two aortic arches in the adult.

The reptiles, though clearly distinguished from them by having cold instead of warm blood and scales instead of feathers, are closely related to the next class, the birds, with whom they are frequently grouped under the name Sauropsida. In the same way the reptiles, birds and mammals, since they all possess the embryonic structure known as the amnion, are ground together under the name, Amniota.

During the Mesozoic period the reptiles reached their maximum, both as to numbers and individual size, so that this period is often spoken of as the "age of reptiles;" the largest of the living reptiles are pygmies compared to the huge individuals of this age.

The reptilia are variously classified by different authors, being divided into from nine to fifteen or more orders. Of these orders, four include the 4000 or more species of living forms, which, of course, are the only ones of economic importance except as mere specimens, or as determiners of geological horizons.

The four orders of living reptilia are as follows:

1. *Chelonia* or *Testudinata*.—These forms are easily recognized by the bony or leathery carapace covering the dorsal side of the body and a flat plastron on the ventral side; these bones are usually covered with horny epidermal plates; the appendages are clawed and adapted for use on land, or are paddle-like for use in swimming. The jaws are armed with sharp bony edges instead of teeth; tympanic membranes

and movable eyelids are present. These are the familiar and easily recognized turtles, terrapins and tortoises.

2. The *Squamata*.—The characteristics of this order, as a whole, are largely osteological so that we shall consider at once the two sub-orders of living *Squamata*, which are sometimes considered as distinct orders; they are the *Lacertilia* and the *Ophidia*. The former are usually provided with legs for walking; nearly always with eyelids and tympanic membranes; the rami of the mandibles are closely united at the symphysis and the mouth can open only moderately widely; a sternum is present; they are represented by the various lizards, such as Geckos, Iguanas, Chameleons, etc. The latter sub-order, the *Ophidia*, are the snakes they are much elongated forms without appendages, movable eyelids, tympanum and sternum; the rami of the mandibles are connected by elastic fibres, and the mouth can be opened to an extraordinary width.

3. The *Crocodylia*.—The body is here more or less covered with bony scales; a sternum is present and also a set of abdominal ribs: the Cloaca is longitudinal in position and sheaths a medium penis; the legs are adapted for walking and the tail is usually compressed for swimming; the teeth are numerous and held in sockets; the ventricle of the heart, in living species, is completely divided. This order includes as living representatives the familiar crocodiles and alligators and also the gavials and caimans, some of which are the giants of the present reptilian world.

4. *Rhynchocephalia*.—This order is represented by a single living genus *Hatteria* or *Sphenodon*; a lizard-like reptile found in New Zealand. Since its only economic importance is as a specimen no further description will be given here.

Chelonia or Testudinata.—The *Chelonia* are, by some, divided into three groups, the turtles, the terrapins, and the tortoises, this division being based chiefly upon the habitat of the species, whether terrestrial, aquatic or amphibious. As these names are employed differently by different authors and in different sections of the world, no attempt will be made here to distinguish between them, and the word turtle will be generally used for any member of the order.

It is as food for man that the *chelonia* are chiefly important, though there are other economic aspects of the group that will be briefly discussed.

Turtles are used for food over practically the entire world, but, it is said, their flesh is forbidden to Mohammedans, and is abhorred by certain Greeks.

Nearly, if not all, species may be eaten, but there is, of course, much difference in the quality of the flesh, and Surface (136) states that during a strike of miners in eastern Pennsylvania many of them were made sick by eating turtles, supposedly the box tortoise, so that the common idea that this form is inedible, at least at certain seasons, is probably correct. There are also a few species whose offensive odor makes them undesirable as food. It is said that even the flesh of the Green Turtle, about to be described, is poisonous at certain seasons of the year in some countries where it is found.

The Green Turtle, *Chelone mydas*, Fig. 95.—This is, perhaps, the most important of the turtles as an article of food; it is an important article of commerce, and is an important part of the diet of some of the tropical peoples. It is found in tropical and semitropical seas throughout the world, and may reach a weight of 500 pounds, though these huge ones are not so good for food; those found in markets usually weigh from 50 to 75 pounds. The name has been given because of the green color of the flesh. Jamaica was formerly, and perhaps still is, one of the chief centres for the Green Turtle industry; Key West has also been an important centre. In one year 15,000 animals were received into England, besides a large amount of dried meat in cans, the meat for canning being cut into strips and dried in the sun, where it acquires almost the consistency of glue and requires long soaking in water before it is fit for food. About 1900 the turtle trade of Jamaica amounted to about \$50,000, and the demand was greater than the supply.

As in many other turtles the oil may be extracted and used for culinary purposes in place of butter or olive oil.

In markets these turtles are kept lying on their backs not only to keep them from escaping but because, being adapted to life in the water, they would not be able to breathe if laid upon a hard surface, right side up; their plastron is not firm, like that of a land form, and the weight of the animal, when not supported by the surrounding water, so compresses the internal organs that suffocation may be produced. The flesh may be cooked in various ways, and is said to be very digestible.

The Green Turtle lays from 200 to 300 leathery-shelled eggs that are

FIG. 95.—Green turtle, *Chelonia mydas*. Esteemed as an article of diet and well known in the markets. Receives its name from the greenish hue of the fat. Large examples weigh 800 pounds. Inhabits all the warmer seas. (From *Ditmars, The Reptile Book*.)

more nutritious than hen's eggs; a dozen of them may be eaten at once. The eggs, which are carefully buried and concealed by the female, are found by prodding in the sand, along the shore, with a sharp stick.

Owing to the decrease in their numbers it has been suggested that these turtles be artificially propagated; it is thought they would reach a marketable size in three years.

Along the Amazon and Orinoko Rivers the eggs of various turtles form a very important article of food; they are preserved by rolling and packing in salt, and in other ways. A kind of oil, much esteemed by the natives, is made from them, preserved in jars, and used like butter. The collection of such enormous numbers of eggs has nearly exterminated the apparently limitless numbers of turtles in some places. The eggs of many of our common fresh-water turtles are good as food if taken from the animal or obtained soon enough after being laid.

The Loggerhead Turtle, *Thalassochelys caretta*.—This is another large, marine form, somewhat similar to the preceding that is sometimes found in the markets, though it is of much less value.

The Diamond-back Terrapin, *Malacoclemmys palustris*, Fig. 96.—This species is supposed to be the most delectable of all the turtles. It is a comparatively small animal, seldom exceeding a length of 7 inches, that is found in the salt marshes of our coast, from Massachusetts to Texas, those of Chesapeake Bay being, perhaps, the most famous. It has been named because of the angular areas made by the concentric lines on the carapace.

The diamond-backs hibernate by burying themselves in the mud along the shore, whence they are tracked and dug out for sale in the markets. Their rarity and comparatively small size, combined with their unusual flavor, cause these turtles to be among the most expensive of our food products. A single animal of 7 inches length is worth about \$6, and the price increases at the rate of about \$1 for each additional half inch in length; a 7-inch specimen weighs about 4 pounds.

At such prices it would seem highly profitable to raise these turtles under artificial conditions. The experiment has been and is still being tried, but the slow growth of the animals and the small number of eggs produced each year make the enterprise a doubtful one from a financial point of view.

The only diamond-back terrapin farm that the author has visited, may be, as claimed, the only one in existence. It is operated by Mr. A. M. Barbee at the Isle of Hope, a suburb of Savannah, Georgia. At this farm may be seen terrapin by the thousands, awaiting shipment to hotels and restaurants of the larger cities. Not only are the live

FIG. 96.—Carapace of diamond-back terrapin, *Malacoclemmys palustris* (*Malaclemmys cantrata*). $\times \frac{2}{3}$.

terrapin shipped but they are preserved in jars and sold in this more convenient form.

The *bulls*, *cows* and *heifers*, as they are called, are kept in separate pens, except during the breeding seasons, and the sick animals are isolated until their recovery or death. The death-rate at the farm is said to be extremely low. The following facts were obtained directly

from Mr. Barbee and from a small book that he has prepared; the book is here quoted freely. "The terrapin are divided into three sizes. The largest are known as the count and measure about $6\frac{1}{2}$ inches. The next are known as the halves and measure about $5\frac{1}{2}$ inches. These are the fine marketable terrapin and can always be counted upon to bring fancy prices. There is also a smaller size known as the quarter, which is also a very good table terrapin. The greater demand is always for the larger terrapin, though the smaller ones are tenderer and sweeter." The length is taken from the lower shell or plastron.

"The demand for terrapin is now very small south of Baltimore. Atlanta, Macon and other cities in the neighboring states usually purchase a dozen or so off and on during the winter to supply the demand of tourists, but there is very little terrapin eaten by the southern whites. It is said that before the Civil War the slaves along the coast countries were fed upon them extensively. With the growing scarcity of the diamond backs the French chefs are now said to be trying to induce the proprietors of the hotels to purchase the cheaper terrapin, promising that when they are through with cooking them the guests will not know the difference. But a man with any taste can easily tell when the flavor of the diamond back is missing. There are very few of the present-day cooks who can prepare a bowl of the famous dish. Diamond-back terrapin stew costs the consumer at the rate of \$2.00 a plate in the larger cities."

The farm on which the terrapin are fattened and kept ready for prompt shipment is 150 feet long and 60 feet in width. It is roofed and securely enclosed against invaders, but is so open that it is perfectly ventilated. The entire place may be flooded at will. The pens or *crawls* are always flooded with salt water to a depth of 4 feet when the terrapins are fed, usually about three times a week in the warmer seasons and not at all during the winter hibernation, when the animals bury themselves deep in the sand. The water is pumped in from the river and in a few hours all the terrapin are swimming, they feed better in the water. After the animals have finished eating, the water is run out of the pens. Shrimp, fiddler crabs, fish, lettuce, celery, etc., are used in feeding. Fresh water is kept running through a trough in the centre of all of the 18 pens into which the farm is divided. The pens are sunk several feet below the level

FIG. 96a.—One of the pens or *crawls* at Barbee's Diamond-back Terrapin Farm, Isle of Hope, Ga., showing the stockade, the central trough for water, the pile of nesting sand, and about 150 diamond-backs. (From Barbee's *souvenir booklet descriptive of his farm.*)

of the ground to prevent the terrapin from digging out. A foundation of brick was abandoned because the terrapin scratched at them until they wore away their claws. For the winter trade the terrapin must be dug out of the sand, sometimes from a considerable depth.

"The trouble in raising terrapin heretofore has always been that the animals in confinement will invariably eat their own eggs. It was many years before I was able to overcome this trouble. Even after I had perfected an incubator I could not fill them because the eggs were either destroyed or were scattered all over the pens, buried out of sight, sometimes at some little depth, which necessitated spading up the entire farm each day to secure them. This process was so disturbing to the terrapin that it was abandoned. One day after feeding, a hillock of sand was left in one of the pens by the receding water. The following morning I found this hillock literally sown with fresh eggs. I have since learned that terrapin always seek elevations in which to deposit their eggs. Now hillocks of sand are carefully prepared and maintained in each of the breeding pens. I have only to turn the sand over with my hands to uncover the eggs." Three sets, with eight or ten eggs in each set, are laid by a female in June, July and August.

"Artificial incubation of terrapin eggs has heretofore been considered an impossibility. Every incubator is carefully marked with the date when the eggs are expected to hatch. There are now 30 incubators on the farm. Incubation in the hatcheries requires approximately 12 weeks' time which is about twice as long as would be necessary under normal conditions."

The incubator consists of shallow, wooden trays divided into compartments and filled with sand and humus in which the eggs are buried.

Terrapin are hatched in the fall of the year and should be allowed to stay in the sand. The mother terrapin never looks after her young.

"Most of our young terrapin are placed in enclosed marshes and allowed to grow and look after themselves. The age of a terrapin is hard to guess. After they get to the size of $6\frac{1}{2}$ inches they are full grown. The male terrapin only grows to be $4\frac{1}{2}$ inches." The enclosed marshes are surrounded by wire netting and are guarded by paid keepers, but as they are located some miles distant from the farm they were not visited by the writer.

"It is hard to believe that these ungainly creatures would exhibit

any intelligence. They know me, however, as a dog knows his master. I have a peculiar clucking sound with which I call them. They will also respond to a whistle. The terrapin will crawl over my feet and almost up my leg to reach their food. They will also come when I wave a handkerchief. It is a rather flesh-creeping sensation to hear the claws of 5000 terrapin scraping over firm sand. From anybody except me the terrapin will flee. He is one of the shyest of creatures. A little noise will confuse and terrify him readily. I once went into the pens wearing a new suit of clothes and a new pair of shoes. I was very much surprised to see my pets fleeing in panic from me in all directions."

The pens are guarded at night against thieves by a number of dogs. These dogs and the terrapin soon become so accustomed to each other that they live together in perfect peace and harmony. The terrapin should be killed by amputation of the head, not by immersion in boiling water, as is often said, and various precautions in dressing and cooking the meat should be taken in order to secure the best flavor.

The Common Snapping Turtle, *Chelydra serpentina*, Fig. 97.—This familiar chelonian inhabits ponds and slow-running streams of the United States east of the Rockies. It sometimes weighs as much as 40 pounds and is named from its habit of snapping at any annoying object with such vigor that human finger may be amputated by a moderate-sized specimen. They are sold in large numbers in some of the greater cities and bring about 10 cents a pound.

The food of the snapper consists of all sorts of animal matter, and it is sometimes very destructive to ducks and other water fowl, destroying entire broods of the young birds. Should the snapper become a pest in the duck pond it may be caught, according to Surface, by baiting a strong fish-hook with a piece of tainted meat and tying the line to a slender stake or tree that will bend when the turtle pulls. The hook must be fastened to the line by a length of slender wire so that the turtle cannot bite it off and escape.

In its feeding habits, then, it is probable that the snapper is more harmful than beneficial; the birds, frogs and fish it destroys more than making up for the insects and other pests that it eats.

The Soft Shelled Turtles, *Genus Trionyx*, Fig. 98. There are several species of soft shelled turtles in the United States, and while they are differently named by different writers they may all be recognized by

FIG. 97.—Common snapping turtle, *Chelydra serpentina*. Large examples weigh about 40 pounds. A vicious species, capable of inflicting severe wounds. Found from southern Canada to Ecuador. (*From Dimars, The Reptile Book.*)

the soft, leathery character of the shell, and by the proboscis-like snout. They are thought by some to be the most palatable of all our turtles

FIG. 98.—Common soft-shelled turtle, *Aspidonectes spinifer*; dorsal and ventral views, and lateral view of head. $\frac{1}{2}$. (After Surface, *Economic Features of Turtles of Pennsylvania*.)

with the exception of the diamond-back, and, as a large specimen may reach a length of 18 inches, they furnish, in some sections, quite a valuable supply of food.

Their omnivorous habits make it difficult to determine their economic importance in this regard. It is said they are very destructive to fish and water-fowl in some regions; on the other hand they may do an important work as scavengers and as destroyers of insects. Many of them are savage in disposition and their jaws are capable of inflicting ugly wounds. Most of them are strictly aquatic in habits, being found in ponds and muddy streams, which they seldom leave.

The Common Box Turtle, Cistudo (Terrapene) Carolina.—This very variable but well-known animal is the slow, plodding tortoise that is found in gardens and fields all over the Eastern States. It is a gentle, harmless animal, as though it realized that its tightly closing shell afforded such perfect protection that offensive actions on its part were unnecessary. As stated above it is probably not fit for food so that its economic importance depends upon its feeding habits. Its food consists of berries and other vegetable matter, including, it is said by some, melons; also insects and other small animals. It is thought by Surface that the destruction of cantaloups on their vines is more than paid for by the destruction of insect pests, so that this species is a friend to the farmer and should be protected.

Among the chelonia that are of less economic importance are the Musk, Map, Red-bellied, Speckled, and Wood Turtles. While most of these are used for food, to some extent, they are all, according to the investigations of Surface, probably of benefit as insect destroyers or scavengers or both.

Other more or less well-known forms are perhaps neither very useful nor especially harmful to the interests of man. In some cases so little is known of their habits that it is impossible to form an opinion of their economic importance.

As subjects for dissection and experimentation almost any of the common chelonia have a certain value and there are several firms that keep them regularly in stock to sell to colleges and other institutions.

The fresh-water turtles that are used for food or for scientific purposes are captured in various ways. Many of them are taken, sometimes scores in a day, by digging them out of the mud or sand in the bottom or along the shores of the ponds or streams in which they live. At the approach of winter they bury themselves in these places and hibernate until spring. With a pointed and barbed rod the hunter prods into the mud and on feeling a turtle pulls it up with the rod.

Turtles are also caught on a line baited with meat, as mentioned above. In the case of the soft-shelled turtle the meat is kept near the surface by a cork. Wire traps, with funnel-shaped entrances like fish traps, are often used and are baited with ears of corn that become sour and attract the turtles. Such traps must be examined at moderately frequent intervals or the turtles may drown. The collection of fresh-water turtles, in some sections, is quite an important industry.

It is seen, then, that most of our fresh-water chelonia are of importance to man, either as food, as scavengers, as insect-destroyers, or as subjects for scientific work.

The Hawksbill Turtle, Chelone imbricata, Fig. 99.—It is from this form, the smallest of the marine turtles, that the "tortoise shell," so valued when made into combs and other small articles, is obtained. A large specimen is about 30 inches long and may be recognized by the overlapping epidermal plates. There are thirteen of these large plates, which are rarely over an eighth of an inch thick; a large animal will yield about 8 pounds. These plates, which are the "tortoise shell," are removed by holding the animal over a fire or by immersing it in hot water. It is said that the natives of the tropics sometimes remove the plates from the living animal, which is then set free to regenerate a new set of plates. This cruel expedient is of no avail as the regenerated plates are probably of no commercial value.

The thin plates are softened and worked at about 100° C. and are welded together with hot irons into layers of the desired thickness. Real shell generally shows the fine lines where the plates were welded together, but there are so many and such perfect imitations of tortoise shell that but few people are able to tell the real article from the best imitations.

India, China, Japan and the West Indies are among the great centres for this article of commerce. The artificial rearing of this turtle also has been suggested.

Lacertilia.—As pointed out in the preceding chapter the lizards and salamanders are seldom distinguished in the popular mind, all being alike called "lizards." In some sections the lizards are called "scorpions," though how this misnomer should have come about is hard to understand.

Another misconception that should be corrected is the very general belief in the poisonous character of the common lizards. As a matter of

FIG. 99.—Hawk's-bill Turtle, *Chelone imbricata*. From this species is obtained the valuable "tortoise shell." It is the smallest of the marine turtles. Found in the warm seas of both hemispheres. Easily recognized by the overlapping shields. $\times \frac{1}{6}$. (From Dalmars, *The Reptile Book*.)

fact all of our lizards are entirely harmless with the exception of the beaded lizards, of Mexico and the extreme southwestern part of the United States, to be described below.

In studying the lizards of Pennsylvania, Surface found no vegetable food in any of the stomachs examined. It is probable that the food of our common lizards, Fig. 100, consists largely of insects, and that they do a great amount of good in destroying these pests and hence should be protected everywhere. Some species seem especially fond of grasshoppers.

The Beaded Lizards, *Heloderma suspectum* and *H. horridum*.—As noted above these lizards are the only ones on this continent, so far as is known, that are venomous. Southern Arizona and New Mexico is the habitat of the first species; western Mexico and Central America of the second. The former, known as the Gila (pronounced *Heela*) Monster, may be seen in many of our zoological parks, and reaches a length of 18 to 24 inches. While tame and good-natured in captivity, it is said to be of a very different disposition in its native environment, and strange tales are told of its ferocity and of its tenacity of grip. Its poison fangs are in its lower jaw and it is commonly said that it turns upon its back, in biting, to cause the poison to flow into the wound; whether or not this be true the writer is not able to say.

There is considerable difference of opinion as the effect of the bite of the Gila Monster, some claiming it to be very deadly to human beings, others holding the opinion that it has but little effect upon man. Ditmars is of the opinion that the beaded lizards are "dangerously poisonous to man." Being easily recognized by the bead-like, brightly colored skin and club-shaped tail there is no reason for confusing these with the harmless lizards, and their restricted range makes them of no importance to the vast majority of our people. Even in their native range they are so scarce that the writer wandered many miles over the Arizona desert searching in vain for a single specimen.

It is probably safe to say, then, that all of our lizards, with the exception of the two species just described, are not only entirely harmless to man and to vegetation but that they are highly useful as insect destroyers.

In many tropical countries both the lizards themselves and their eggs are largely used as food. It is the huge Iguanas, Fig. 101, reaching a length of six or more feet, that are chiefly used in this way. The flesh is

FIG. 100.—Common swift; fence lizard, *Sceloporus undulatus* (upper). Spiny swift; Texas swift, *Sceloporus spinosus* (lower). $\times 7$. The species figured live mostly on the trunks of fallen trees, scurrying about in search of insect prey. On the throat and abdomen of the males are brilliant blue patches. (From Ditmars, *The Reptile Book*.)

FIG. 101.—Iguana, *Cyclura carinata*. A West Indian species, closely allied to the Iguanas that inhabit the extreme southwestern portion of the United States. $\times \frac{1}{8}$. (From *Dilmars, The Reptile Book*.)

said to be of delicious flavor, resembling chicken. In the Bahamas the lizards were formerly one of the most important articles of food; they were hunted with dogs and kept in captivity till wanted. They have been hunted almost to the point of extermination in some places.

Ophidia.—Of all the vertebrates the Ophidia or serpents are probably the most universally and undeservedly hated by man.

While not one of the more important groups economically the Ophidia have sufficient importance to warrant some discussion, and the majority are, to say the least, quite harmless and inoffensive.

Dividing the Ophidia into two main groups, the venomous and non-venomous snakes, it will be found that the former is much the smaller group and it will be discussed first.

It is generally said that all of the venomous snakes of the United States are included among the rattlesnakes, the copperhead, the moccasin, and the coral snakes; but, according to some authors, the so-called opisthoglyph snakes should be included among the venomous serpents. As indicated by the name, the opisthoglyph snakes have their poison fangs, which are small and grooved, in the *rear* part of the upper jaw, so that a person may be bitten by one of these snakes without being pierced by the poison fangs and hence without unpleasant results. Some of these snakes are too small to have any effect upon man, others are large enough to produce unpleasant though probably not serious results. They are found only in the far south especially along the southern borders of Texas, Arizona, and New Mexico. So far, then, as the vast majority of the people of the United States are concerned the venomous serpents are included among those mentioned above, and it is a very simple matter to distinguish these few from the much greater number of harmless ones. The idea that several of our common and harmless snakes are venomous is so deep rooted that it is difficult to make people believe otherwise.

Of the really venomous forms the Elapine snakes are the rarest. They include two beautiful snakes in this country, the Harlequin or Coral Snake of the southern states and the rare Sonora Coral Snake of southern Arizona and Sonora, Mexico. Both snakes belong to the genus *Elaps*, and are related to the deadly Cobras of the Orient.

The Harlequin Snake, Elaps fulvius.—This is a comparatively small, slender snake, rarely reaching a length of a yard. It is found from North Carolina through the Gulf States into Central America.

In the Mississippi Valley it may be found as far north as southern Ohio. It is strikingly colored with transverse scarlet and black bands, separated by narrow yellow bands. It is strikingly similar in its coloration to the harmless Scarlet King Snake, but in the latter the black bands border the yellow, instead of the yellow bordering the black. It has a small head, with an indistinct neck, and is more or less subterranean in habits. Its pupils are round like those of the nonvenomous snakes.

Just how serious to man is the bite of the Coral Snake it is difficult to say; Ditmars thinks that in spite of its small fangs "It should be placed in the list of dangerously poisonous snakes," but its striking coloration and secretive habits cause it to be of little danger to man even within its rather restricted range.

FIG. 102.—Head of rattlesnake, dissected to show the oval poison gland behind and below the eye, and the curved duct connecting gland with fang. "Pit" is between eye and nostril. $\times \frac{2}{3}$.

The Viperine Snakes, or pit vipers include the well-known and widely distributed venomous snakes, the Rattlers, the Copperheads, and the Moccasins. These are all thick-bodied forms, with flat, triangular heads, distinct necks, elliptical (not circular) pupils, and with the highly characteristic "pit" between the eye and the nostril. This pit, Fig. 102, whose function is unknown, is large

enough in probably all cases to be seen at a greater distance than its owner is able to strike (as a rule a snake can strike only one-half or two-thirds of its length), and may be taken as a sure sign that its possessor is venomous.

The fangs of these vipers consist of a large, curved, hollow tooth near the front of the upper jaw on either side, Fig. 103. Strange as it may seem, many people call the forked, quivering tongue the fang; whatever function or functions the tongue may have, it is perfectly harmless. The fangs are surrounded by sheaths of soft tissue, and when the mouth is closed they lie up against the upper jaw, with the needle-like point toward the rear; the sheaths almost hide the fangs, even when they are erected for striking. Each fang is connected with the duct of a

poison gland, the latter lying in the side of the head behind the eye, Fig. 102.

The fangs are shed at intervals of about three months, and it is not very unusual to see two fangs on one side of the jaw; the skull of one of these vipers will show a series of fangs, one behind the other, Fig. 103, ready to replace the functional ones when lost. It is evident,

FIG. 103.—Skull of a pit viper, showing functional and developing fangs. Also disarticulated symphysis of lower jaw. Enlarged. (From *Ditmars, The Reptile Book*.)

then, that removal of the fangs of these serpents renders them only temporarily innocuous, perhaps not even temporarily so, as poison would probably enter the wounds caused by the ordinary small teeth of the snake.

The effect upon the human system of the bite of our pit vipers depends upon several conditions: the size of the snake, the location of the wound, and the promptness and character of the treatment.

The copperhead, which is the smallest representative of the three groups of pit vipers, except some of the smallest rattlers, perhaps never proves fatal to a human adult, at any rate the author has never heard nor read of a fatal case, though he has met several persons who had been bitten by this species of snake.

The moccasin, to be described later, though belonging to the same genus as the copperhead, reaches a much larger size, and may inflict a fatal wound.

The bite of one of the larger rattlers may cause the death of a man within an hour's time, while some of the "ground" or pigmy rattlers are so small that their bite would probably not be a very serious matter to a healthy man.

To illustrate the virulence of rattlesnake venom the author put a mouse in the cage with a young Timber Rattler scarcely more than a foot long. With a single, lightning-like stroke the rattler hit the mouse, which dropped in its tracks and, with a convulsive quiver, was dead in less than 15 seconds. Other mice, when struck by the same snake, lived for a much longer time, probably not having been struck in so vital a spot.

Although so deadly, there are extremely few deaths in this country from the bite of rattlesnakes and other venomous serpents; this is in marked contrast to some of the tropical countries; in India, for example, more than 20,000 people are killed each year by poisonous snakes. This high mortality is doubtless due not only to the great abundance of snakes, but also to the fact that a large proportion of the dense population goes about with bare feet and legs, thus giving the short-fanged serpents of that region every opportunity to get in their deadly work. The fangs of even some of the large cobras of the orient are so short that, it is said, they cannot reach the flesh through ordinary clothing, so that Europeans living in these cobra-infested regions are not often injured.

Records of serious or even fatal accidents with rattlesnakes in captivity are fairly numerous.

As to the best treatment of injuries from venomous snakes authorities differ somewhat, though the general treatment that is recommended is about as follows, promptness being of prime importance: if the wound be upon the arm or leg, and it nearly always is, immediately put a tight ligature (a handkerchief twisted with a stick, if nothing better be

at hand) above the wound to stop, as far as possible, the circulation; this ligature should not be left on more than half an hour as gangrene may set in otherwise; after applying the ligature cut open the wound with a sharp knife to cause free bleeding; some authorities say to suck the blood from the wound with the lips, others say this does the patient no good and may poison the person who does the sucking if he happen to have any sores in his mouth. The wound should now be thoroughly washed with a strong solution of potassium permanganate in water, or, better, the solution should be injected into the wound with an hypodermic syringe; in the meantime, a physician should be got as soon as possible.

The old idea that intoxicating doses of alcohol are of use in such cases is no longer held; the patient may recover in spite of such treatment, not because of it. Slight doses of alcohol may sometimes be useful as a stimulant, and in some cases hypodermic injections of strychnia may be necessary. Tincture of iodine is recommended by some for washing out this wound, but the potassium permanganate solution seems to be the accepted and easily obtainable antidote for the poison.

It should be remembered that a snake wound is unusually susceptible to blood poisoning, so that it should be kept carefully washed and covered with aseptic solutions and cloths. Animals killed by snake venom decompose rapidly because of the decrease in bactericidal power of the blood caused by the venom.

Venoms of various snakes vary greatly in their toxic properties, the most important types being: (1) those which attack the nervous system; (2) those which attack the blood corpuscles; (3) and those which cause hemorrhages by attacking the endothelium of blood vessels.

Antivenom sera are now on the market that, when injected hypodermically into some part of the body where they will quickly get into the circulation, produce good results in combating the venom. Their use is strongly advocated by some authorities; but, to be effective, they must be injected within a few hours after the bite has occurred. According to Ricketts and Dick the antivenin of Calmette is not effective against all snake venom as was formerly claimed.

It is certainly well for those who travel in some sections of the country, where the larger rattlers or moccasins abound, to carry a small case containing some crystals of potassium permanganate, an hypodermic syringe, a rubber ligature, some gauze, some disinfectant, and a

FIG. 104.—Water moccasin or cotton-mouth snake, *Ancistrodon piscivorus*. Reaches a length of 5 feet.
(From Dilmars, *The Reptile Book*.)

very sharp scalpel. Heavy leggins will, of course, greatly diminish the danger of being bitten.

The Water Moccasin or "Cotton-mouth," Ancistrodon piscivorus, Fig. 104. Since this reptile is confined to the South Atlantic and Gulf States and the lower Mississippi valley it is of no direct interest to a large portion of the country. It is a thick-bodied snake that may reach a length of 4 or 5 feet. The characteristic markings seen in young animals may disappear with age, so that it may not be easy, at first, to recognize this species; but if the pit and elliptical pupil be there, beware! In its native haunts this snake is active and rather aggressive, and is very justly dreaded, as the bite of a large cotton-mouth may prove fatal. It is usually found in swamps and along sluggish streams, hanging on bushes or lying on half sunken logs. Its popular name is doubtless derived from the white mouth-parts exhibited by the snake as it opens its mouth before striking.

There are several water snakes that are popularly called "moccasins" and are commonly supposed to be venomous, but they are quite harmless, in spite of their willingness to bite; they, of course, do not possess the pit nor the elliptical pupil, nor do they reach the large dimensions of the cotton-mouth. The writer has been bitten by these so-called "moccasins" without the slightest ill effects. Because of the character of its habitat there are probably few serious accidents caused by the "cotton-mouth" but it would be well for those living within its range to become familiar with its appearance.

The Copperhead Snake, Highland Moccasin, etc., Ancistrodon contortrix, Fig. 105. This snake, which is pretty generally distributed over the eastern and southern part of the United States, is, as the name shows, a close relative of the preceding. It is somewhat variable, but usually shows more distinct markings than the moccasin—chestnut bands across a lighter ground color. The name comes from the distinct coppery color of the top of the head. It is not so large a snake as the preceding, seldom, if ever, reaching a length of 4 feet; most of the specimens seen by the author have been under 3 feet. It inhabits dry, rocky regions, rather than swamps, hence one of its popular names "Highland Moccasin." It is also frequently found in cultivated fields. There are several perfectly harmless snakes, to be noted below, that are frequently mistaken for the copperhead, but the pit and elliptical pupil will distinguish the latter.

FIG. 105.—Copperhead snake, *Ancistrodon contortrix*. Seldom exceeds 3 feet in length. (From Ditmars, *The Reptile Book*.)

While a properly directed bite of a large copperhead might prove fatal, the author, as noted above, has never heard an authentic report of a death from the bite of this species.

In many thickly settled parts of the country the copperhead has been practically exterminated, but in other regions it is uncomfortably abundant.

FIG. 106.—Diamond rattler, *Crotalus adamantous*, caught alive in Florida.

The Rattlesnakes, genera Crotalus and Sistrurus, Fig. 106. Little need be said of these most famous of our American serpents. It is unnecessary here to look for the pit nor for the elliptical pupil, since that curious structure, the rattle, is always to be found at the end of the tail; and he who has once heard that ominous sound is not apt

to forget it. Like the copperhead, the rattlers have been practically exterminated in many thickly settled places, but there are few regions of any extent in the country where at least one species may not be found.

Something over a dozen species are recognized in the United States, nearly all of them falling under the genus *Crotalus*.

They vary in size from the terrible Diamond-back *C. adamanteus*, Fig. 106, of the southeastern part of the United States, one of the most deadly of all serpents, which may reach a length of 8 feet and a diameter of 4 or more inches, to the Pigmy or Ground Rattler of Florida, *Sistrurus miliarius*, adult specimens of which may be less than 18 inches long; the difference in the effects of the bites of these two species is correspondingly great.

Since the rattler usually sheds its skin three times a year, and since a new segment is added to the rattle at each shedding, by allowing the "button" and first ring for the first year, the age of the snake may be calculated by the number of segments in the rattle, *provided* some of the segments, as is often the case, have not been lost.

The treatment of rattlesnake-bite has been dealt with above.

It will be seen, then, that it is a comparatively simple matter for anyone to learn to recognize the venomous serpents of his locality, and such information may, at some time, be of vital importance to its possessor.

Let us now turn to that much larger group, the non-venomous snakes, a number of which will be mentioned briefly. Many will not be mentioned, either because their economic value is debatable or because of lack of information in regard to their habits.

The Garter Snakes. Genus Eutænia.—The Striped Snakes are the most abundant of North American serpents, and are found over the entire continent, wherever snakes are found. The numerous species are extremely variable, but most people that know anything about snakes recognize the garter or ribbon snakes of their region. They are usually small, 2 feet or less in length, and most of them have one or more longitudinal stripes. They all produce their young alive and in large numbers. Since they feed entirely upon cold-blooded animals, frogs, toads, fish, etc., they are not only not useful to the farmer, but should be considered of some negative importance as destroyers of useful animals, though, possibly, the very young snakes may be of use

FIG. 107.—Common water snake, *Tropidonotus fasciatus sipedon*. Characterised by the bands on the posterior part of the body breaking into alternating blotches. The common water snake of the northeast. Reaches a length of 4 feet. (From Dilmars, *The Reptile Book*.)

as destroyers of insects or insect larvæ; at least they are entirely non-venomous.

The Water Snakes. Genus *Tropidonotus*, Fig. 107. Under this genus are several dozen species of semi-aquatic snakes, many of which are well known. Since, like the garter snakes, their food consists of frogs, toads, fish and other cold-blooded animals, they are probably of no benefit to man, and may do some harm in destroying useful animals. Many of them are of ugly disposition and will strike with sufficient force to bring blood, but they are all entirely non-venomous. Among the better known forms under this genus are the Common Water Snake, *T. fasciatus*, *sipedon*, found from Maine to North Carolina and west to Kansas; the Banded Water Snake or Moccasin, *T. fasciatus*, which extends from Virginia south; and the Brown Water Snake or Water Rattle, *T. taxispilotus*, the largest of American Water Snakes, reaching a length of 5 feet and with a thick body, found in the States south of the Potomac and east of the Mississippi.

One of the chief points of interest in connection with these Water Snakes is the fact that they are so frequently confused with the deadly "Cotton-mouth" Moccasin, or, if recognized as distinct, they are thought to be venomous themselves. The Banded Water Snake, in particular, with its thick body and flat, distinct head, is easily mistaken for the venomous species, but the pit and the elliptical pupil will distinguish the latter unfailingly.

The Brown or Ground Snakes.—This group of small snakes, measuring from 8 to 14 inches in length, is represented by several genera, most of which are of retiring, even subterranean habits. They are of a dull brown color above, with few, if any markings; the ventral side is white, yellow, pink, or vermilion, depending upon the species. Since their food consists of insects, insect larvæ, slugs, etc., they may be considered highly beneficial, and their diminutive size and gentle habits leave not the least excuse for their destruction. They are distributed over practically the entire United States and southern Canada east of the Rockies.

The Racers. Genera *Spilotes* and *Zamenis*.—Several well-known and useful serpents are found in this group. Under the first genus is found the Gopher, Indigo or Rat Snake, *S. corais couperi*, a large snake with shiny black scales, both above and below, but with reddish chin and throat. It may reach a length of 8 feet or more. It

FIG. 108.—Blacksnake; racer, *Zamenis constrictor*—Southern phase. This Southern phase has more white on the chin and lip plates than the Northern blacksnake. Reaches a length of 6 feet. (From Dilmar, *The Reptile Book*.)

is found in the South Atlantic and Gulf States, where its value as a ratter is often recognized; it is encouraged to live about barns and out-houses and is regarded almost as a pet.

The Blacksnake or Black Racer, Z. Constrictor, Fig. 108, is a dull rather than a glossy black, has a white instead of a reddish throat, and has smooth not keeled scales. It is fairly slender and may reach a length of 7 feet, possibly more. It is not a constrictor. According to Nelson "They frequently pursue people when they retreat, but retreat themselves when the person pursues them." It is abundant east of the Mississippi; further west it is replaced by the Blue Racer, variety *flaviventris*, with similar habits. This species is of great value to agriculture as a destroyer of destructive rodents, but in spite of this it is very generally killed by farmers and others just "because it is a snake."

The Rat Snakes. Genus Coluber.—These so-called Rat or Chicken Snakes are usually large, and since they feed on warm-blooded animals most of them are of value to man as destroyers of rodents, though some destruction of birds is caused by some species.

The Fox Snake or Red-headed Coluber, C. vulpinus, named from the fox-like odor of newly captured specimens, is a fairly large, brownish, spotted snake found throughout the Central States, where it is of distinct value to agriculture as a destroyer of rodents; since it often seeks its prey in the vicinity of barns it is sometimes called the House Snake.

Emory's Coluber or Spotted Chicken Snake, C. emoryi, is another useful *Coluber* found in the states west of the Mississippi, from Kansas south.

The Red Coluber, C. guttatus, called variously the Corn, Red Chicken, Mouse, or House Snake, is a fairly large snake inhabiting the states south of Pennsylvania and east of the Mississippi. Its pale red back, with crimson saddles, and its white belly with large black squares, make it easy to recognize. It is useful as a destroyer of rodents.

The Black Coluber or Pilot Blacksnake. C. obsoletus.—This snake may reach a length of 8 feet or over and is frequently confused with the Common Blacksnake or Racer, from which it may be distinguished by its keeled and polished scales. It is found practically all over the states east of the Mississippi and into Texas, and is a useful

rodent destroyer, though it does some damage to poultry and wild birds.

The Four-banded Coluber, Banded or Yellow Chicken Snake. C. obsoletus quadrivittatus.—This snake is found in the states from North Carolina south, and west to the Mississippi. It is sometimes found on the rafters of barns and chicken houses where it feeds not only upon rats and mice but also upon eggs and young chickens. Whether the harm it does in destroying poultry is more than balanced by the good it does in destroying rodents is hard to determine.

The Bull Snakes. Genus Pituophis, Fig. 109. The three species of this genus, found in various parts of the country, are useful since they feed largely upon destructive mammals.

The Green Snakes. Cyclophis æstivus and Liopeltis vernalis.—These small snakes are easily recognized by their uniform green color above; the former, the Keel-scaled Green Snake, is the larger, has keeled scales, as the name indicates, and is yellowish beneath; the latter, the Green or Grass Snake, is whitish beneath, has smooth scales, and is rarely over 20 inches long. They are very gentle snakes and are useful as destroyers of insects.

The King Snakes. Genus Ophibolus.—This group includes some of our well-known snakes, harmless to man, but often destructive to venomous and other snakes; hence their popular name. They are useful to man not only as destroyers of dangerous serpents but as destroyers of mammalian pests.

But two representatives of this group can be mentioned here; the Common King Snake, Chain Snake, or Thunder Snake, *O. getulus*, and the Milk or House Snake or Spotted Adder, *O. doliatus triangulus*.

The Common King Snake, Fig. 110, is a variable species that is found generally over the United States south of latitude 40°. It may reach a length of 5 feet or more, and is usually black or dark, with narrow whitish or yellowish lines across the back in a pattern somewhat like the links of a chain, hence one of its popular names. This snake, so gentle toward man, not only destroys other snakes, but seems quite immune to the venom of the deadly serpents.

The Milk Snake is also variable and widely distributed, and is named from the supposed habit it has of sucking milk from cows; this snake does not steal milk, but is quite useful as a destroyer of rodents, espe-

FIG. 109.—Common bull snake, *Pituophis sayi*. Largest of the North American serpents. Found in the plains region and the west. Reaches a length of 9 feet and a circumference of 6 inches. (From *Dilmars, The Reptile Book*.)

FIG. 110.—Common king snake or chain snake, *Ophibolus getulus*. Reaches a length of 6 feet. Gentle toward man, but kills and eats venomous and non-venomous serpents, and is immune to the bite of the former. (From *Ditmars, The Reptile Book*.)

cially about barns and houses which it may frequent; from this habit it gets the name of House Snake.

The Hog-nosed Snakes. Genus Heterodon.—Practically the entire United States is inhabited by one or other of the three species of Hog-nosed Snakes. They are blotched or black snakes with rather thick bodies and strangely upturned snouts that give the popular name. They have the flat, distinct head that is supposed to be characteristic of venomous serpents, and this, with the habit they have of swelling up the body with air and then blowing it out with a hissing sound, has caused them to be almost universally considered venomous, though they are entirely harmless to man. This curious habit has given the popular name of Puff Adder or Blowing Viper. Their tendency to live in dry places has doubtless given rise to the name Sand Viper. Since these snakes are said to feed chiefly upon toads and frogs they cannot be said to be beneficial to man, but rather the reverse.

Among some savage and even civilized peoples the boas and other large snakes are often used for food. The meat is firm and white, and is said to taste somewhat like veal. Snake eggs also are used for food, it is said.

Snake "wine" is sold in China, and in this country rattlesnake oil is sold as a medicine, which, it is claimed, is good for various aches and pains, though its medicinal value is probably no greater than that of any common animal oil.

Crocodylia.—More than 100 years ago attempts were made to utilize the skin of the alligator, but it was not until about 1855 that these attempts were successful and alligator leather became somewhat fashionable and some thousands of hides were converted into leather. The demand was short-lived, however, and was not again felt until the demand for shoe-leather during the war between the States revived the business. At the close of the war the business again failed, but about 1869 the demand became greater than ever and has continued unabated almost to the present time. The supply of skins from our own States proving inadequate, large numbers of skins were soon imported from Mexico and Central America. The skins from South America are so heavy that they are of little value in making leather. Of the States of the Union, Florida has been the chief producer, the most important centres for hides being Cocoa, Melbourne, Fort Pierce, Miami, and Kissimmee. Ten men at the first-named place took, in 1899-1900,

2500 skins; one man took 800 skins in 1 year; another man collected 42 skins in one night. At Fort Pierce 12 men took 4000 skins in 1889. In 1899, three firms at Kissimmee handled 33,600 hides. After this time the total number of hides taken and the average per man diminished greatly.

Besides being killed for their hides, the alligators have been destroyed by the thousands merely for wanton sport, so that in 1902 it was estimated their numbers in Florida and Louisiana were less than one-fifth of what they were 20 years before that time, and unless steps be taken to prevent it, the alligator hide, as an article of commerce, may cease to exist in our Southern States.

It has been claimed that the destruction of the alligator has allowed the cane rat and muskrat to increase to a serious extent, the former doing great damage to crops, the latter often injuring the levees to a dangerous extent. Legislation to forbid the killing of alligators of less than 4 or 5 feet in length has been suggested and should be passed, since animals of less size have almost no commercial value for leather.

In 1902, the annual output from the tanneries of the United States approximated 280,000 skins, worth about \$420,000. Of these about 56 per cent. came from Mexico and Central America, 22 per cent. from Florida, 20 per cent. from the other Gulf States. South American hides are not handled by the United States markets.

Probably the greater part of the hides from Mexico and Central America are those of the Caiman.

In 1908, there were marketed from the South Atlantic and Gulf States 372,000 pounds of alligator hides, valued at \$61,000.

According to the United States Bureau of Fisheries the hunter in 1891 averaged about 60 cents for the skin, while in 1902 the price averaged about 90 cents, varying between 15 cents and \$2, depending on the size and condition of the skin. "Prime hides 5 feet long, with no cuts, scale slips, or other defects, are worth about 95 cents each, in trade, when the hunter sells them at the country stores, and about \$1.10 cash, at the tanneries. Those measuring 7 feet are worth \$1.55; 6 feet, \$1.12; 4 feet, 52 cents, and 3 feet, 25 cents. Little demand exists for those under 3 feet in length" (Report of Commissioner of Fish and Fisheries, 1902, p. 345). Hides of 7 feet are in most demand, those over 10 feet are not much used. The income

of the hunters is largely increased by the sale of otter, bear, deer, and other skins.

"The skin should be removed soon after death as, in warm climates, putrefaction sets in very early and the value of the skin is depreciated. After removal, the flesh side of the skin is thoroughly rubbed with fine salt, and the skin is carefully rolled up with the salted side inside and is ready for shipment, but must be kept in a dry, cool place. Great care must be taken not to cut the hide since small cuts that are not noticeable in the raw skin may be so conspicuous in the dressed skin as to render it of much less value; a large percentage of the hides received in the markets are thus damaged.

"Formerly only the 'belly skin' was removed, by two longitudinal incisions just below the horny portion of the back; but it was later found that the thick horny skin of the back could be tanned nearly as well as the thinner belly skin, so that the entire skin is now usually removed by a longitudinal incision along the mid-ventral line, with lateral incisions along each leg to the foot. The entire skin is more commonly taken in Mexico and Central America than in our States, Fig. 111.

"Although the raw skins are sold according to length, the tanned hides are sold by the width of the leather at the widest part. Standard hides sell for \$1.00 to \$1.65 per 12 inches of width. Some skins tanned and dyed in a superior manner sell for \$2 or more for single skins of $2\frac{1}{2}$ feet in length. As a rule the Louisiana skins fetch the highest prices, and those from Florida the lowest. Imitation alligator leather is now prepared in large quantities, principally from sheepskins or the buffing from cowhides. These are tanned according to the usual process, and before the skins are finished they are embossed with the characteristic alligator markings by passing them between two rollers." (Above-mentioned report, p. 346.)

Very little of the leather is now used in making shoes, the chief demand being for handbags, music-rolls, etc. In fact at the present time (1919) alligator leather is so little in vogue that the business is said to be nearly dead.

In hunting alligators for their hides two methods are usually employed, in the Southern States at least. The common method is "fire-hunting" at night; the hunters go, either singly or in pairs, usually in boats, sometimes on foot, with shotgun and torch. The torch may be fastened to the hunter's hat, after the manner of the miner's lamp. A more progressive hunter, employed by the writer had, as a torch, an acetylene lamp, attached to his hat, with the tube for the gas extending down his back to the generator in his pocket. This lamp

FIG. III.—Skins of alligator. "Belly" skin on left; whole skin on right. (From Stevenson, *Utilization of the Skins of Aquatic Animals*, in Report of U.S.F.C. 1902.)

threw a blinding beam of light far across the swamp into the eyes of the unsuspecting 'gator, which usually remained fascinated until it could be approached to within easy range. A shotgun at close range, of course, blows off nearly the entire top of the animal's head and kills it instantly; it is then seized before it sinks out of reach and is either taken into the boat or dragged upon the bank to be collected with others in the early morning.

In daylight, with no glaring light to hypnotize it, the alligator is difficult to approach within range and it usually disappears into its cave before the hunter can get a shot at it. The daylight hunter, then, should be supplied not, of course, with a light, but with a 10- or 15-foot pole with a large iron hook at the end. If the alligator be vigorously prodded with this mammoth fish-hook he will usually finally seize it with his mouth and can be pulled out of his hole alive. It is then an easy matter to kill him with a bullet through the base of the brain. I have seen an 8-foot alligator thus killed with a little .22 calibre "cat" rifle. An 8-foot alligator will often be all that two men can manage to drag out of his cave in this way; and, in the torrid heat of the southern swamp, this violent exercise is not to the liking of the usually not very energetic hunter.

While the manufacture of leather gives or gave the chief value to the alligator there are other ways in which it has some economic importance. Chief of these is probably the sale of alligator goods to tourists. In 1891 there were in Jacksonville, Florida, twelve dealers in live and stuffed alligators. In 1890, 8400 alligators were sold to tourists, the price for the live animals varying from \$10 to \$35 per hundred. For individual animals of the smallest size (less than 12 inches long) the price is usually from 50 cents to \$1. For a 3-foot alligator the price is generally \$3 to \$5; for sizes over 3 feet \$2 per foot may be charged, though for very large specimens the price may be from \$50 to \$300 each.

Besides the live and stuffed animals, the teeth are polished and sold as souvenirs; about 450 pounds of teeth were sold in 1890, at a price varying from \$1 to \$2 per pound. From 75 to 200 teeth will make a pound.

In 1891 about forty people, in addition to the regular dealers, were engaged, in the United States, in stuffing alligators, polishing teeth, etc. The teeth are extracted by burying the head until decomposition sets in.

The tiny alligators that are most commonly sold to tourists, to be brought North, perhaps, and allowed to freeze or starve to death, may either be caught by a wire noose at the end of a fishing rod, or they may be hatched from eggs that are taken from the nests shortly before they are ready to hatch. Such eggs may readily be hatched by simply keeping them moist and at a fairly constant temperature. Besides the above uses Ditmars says:

“The eggs are eaten in many portions of the South, and the search for eggs at the proper season furnishes profitable employment for many persons, as each nest contains a large number of eggs, about 30 in the average nest.”

Never having eaten an alligator egg I cannot speak from personal experience of its flavor; but it has always seemed strange to me that more use is not made of the flesh of the alligator. This flesh is often said to have too strong a flavor to be palatable; I have eaten it, and it had no rank taste but was decidedly agreeable, being, as might perhaps be expected of so amphibious an animal, somewhat like both fish and flesh, yet not exactly like either. Perhaps greater care should be taken in skinning an animal that is to be used for food in order that the flesh be not tainted with the musk. It may be a lack of care in preparation that has given rise to the impression that alligator meat is too strong to be pleasant. It is perhaps, also, the “idea” of eating a reptile that makes the meat unpopular. A half-grown boy, who was once in the swamps with me, had expressed a great aversion to alligator meat, so the guide, one day, offered him a nicely fried piece of alligator meat, saying it was fish; the meat was eaten with evident relish and the diner was not told until after a second piece had disappeared what he had been eating. It always seemed strange that the poor people of the South should not more often vary the monotony of fat pork and corn bread with alligator steaks. Whether the meat could be smoked, salted, or canned so that it would keep in a hot climate I do not know; I am not aware of any experiments along this line.

An article by the writer on “Reptiles as Food,” which appeared in the December, 1917, number of *The Scientific Monthly*, having excited the curiosity of the members of a large boarding house in Morgantown, W. Va., it was suggested that a collection be taken among those interested to buy a couple of small alligators and have them cooked, to see if the flesh really was as agreeable as was claimed in the

article in question. The writer agreed to buy the animals and prepare the flesh for cooking.

Sufficient funds were collected to buy, of the Arkansas Alligator Farm, two alligators, each about three feet in length. These were killed by cutting the cord at the base of the skull, and the flesh of the entire body was cut into pieces of suitable size for cooking.

The meat was first parboiled (though the necessity for this was doubtful) and was then fried in egg and cracker crumbs, very much after the manner of a breaded veal cutlet.

About thirty people, consisting of both men and women, mostly school teachers, members of the university faculty, and college students, partook of the repast, and all declared the meat to be "delicious."

There was considerable difference of opinion as to what the meat resembled: some thought it tasted like pork; some thought it like fish; one person said it suggested lobster; but all declared it to be most agreeable.

Of course, at the prices charged by supply firms the cost of live alligators would be prohibitive, but in the tropics, where crocodilia are often extremely abundant, the flesh could be had at a very low cost.

The writer has seen alligator hunters, in our southern states, throw hundreds of pounds of alligator meat to the carrion crows and buzzards, after removing the hides.

Whether the Central and South American crocodiles would be as pleasant for food as the Florida alligator the writer can not say.

While the Crocodilia of this country are practically harmless to man, there are one or two species found elsewhere of which this cannot by any means be said. The African Crocodile, *C. niloticus*, for example, is said to destroy more human lives than all other wild animals of the Dark Continent combined; and the Salt Water Crocodile, *C. porosus*, according to a British Blue-book, caused 244 deaths in British India in the year 1910. The black caiman, *Caiman niger*, of South America sometimes attacks small domestic animals and children; even grown people may at times be attacked.

CHAPTER XIII

AVES

The characteristics of this familiar class are more definite and unvarying than those of almost any other class in the animal kingdom. Birds are known by their feathers, which are possessed by no other animals. They are warm-blooded, in which they differ from all preceding forms, their blood being several degrees warmer than that of man and other mammals.

In almost all living species the anterior appendages are developed as wings and are used in locomotion. To support the large pectoral muscles used in flight the sternum is usually prolonged into a ventrally projecting keel or carina.

In all living birds teeth are absent. The olfactory organs are usually poorly developed while the eye is unusually large and perfect and contains a pecten. The cervical vertebræ are usually numerous while the caudal are few and are usually fused to form a pygostyle around which the tail feathers are attached. The coracoid is usually large and pillar like; the clavicles are united to form the familiar "wish bone;" and the scapula is long and sabre-shaped. There are numerous other internal peculiarities that might be mentioned, such as the absence of the left instead of the right (as in mammals) aortic arch and of the right ovary and oviduct; the frequent enlargement of the gullet to form a crop or craw; the division of the stomach, in some forms, into the glandular part or proventriculus and the hard, muscular gizzard; the presence of air spaces in the bones and in various parts of the body that are connected with the lungs; the presence of a peculiar voice apparatus, the syrinx, situated at or near the point of division of the trachea into the bronchi; the four-chambered heart containing oval, nucleated, red-blood corpuscles.

Birds are all oviparous; the egg is large in proportion to the bird that produces it and consists of a large amount of yolk and albumen inclosed in a hard, calcareous shell. The newly hatched young are either

covered with down and are able to run about or they are more or less naked, blind and helpless; in the former case they are said to be precocious, in the latter case they are called non-precocious or altricial.

Owing to their common occurrence about the haunts of man and to their attractive appearance and songs birds have been more generally studied than almost any other class of animals. Unfortunately, however, owing again to the beauty of their plumage and to the delicious flavor of their flesh, they have been hunted by man almost, or quite, in some cases, to the point of extermination. Of recent years, fortunately, partly through the efforts of the Audubon and other similar societies, and through the work of the United States Biological Survey, a widespread interest in the study and protection of birds has done much to arouse public sentiment and cause the enactment of protective laws, such as the McLean Federal Bird Law. This campaign of education, to be noted later has already begun to bear fruit and the birds in many localities are increasing in numbers in a very gratifying way.

There are so many and such excellent bird books and illustrated guides (see bibliography) on the market that only a few of the ways in which birds are of economic importance to man will be here noted. For the same reason space will not be given to the discussion of poultry and other common domestic birds, since that is a science in itself and is represented by a large library of literature.

The classification of the birds is so complicated and unsettled that little will be said of it here. Practically every text-book uses a different method from the rest, but most authors divide the class, which is estimated to contain 10,000 to 12,000 species, into two sub-classes: 1. **Archæornithes** and 2. **Neornithes**. The former contains the single species *Archæopteryx lithographica*, Fig. 112, the interesting Upper Jurassic form that possess the teeth, claws, long tail, etc., of the reptiles but the feathers characteristic of birds. It is an excellent example of a connecting type, showing the descent, that is also indicated in other ways, of the birds from reptilian ancestry.

The latter sub-class contains the living birds, and also a few extinct forms which, while most interesting, have no economic bearing and hence will not be discussed here. The Neornithes, in older texts, are sometimes placed in two "Divisions"—A. Ratitæ and B. Carinatae, and as a matter of convenience, these divisions will be used here.

The Ratitæ include several extinct forms, some of great size, and a

few modern birds that are characterized, by the absence or vestigial character of the wings, with corresponding changes in the structure of the sternum (not keeled), coracoid and other bones. They are prob-

FIG. 112.—*Archaeopteryx lithographica*. $\times \frac{1}{4}$. *c*, carpal; *cl*, furcula; *co*, coracoid; *h*, humerus; *r*, radius; *sc*, scapula; *u*, ulna; I–IV, digits. (From Hegner, College Zoology, after Zittel from Steinman and Döderlein.)

ably degenerated descendants of originally winged ancestors. The best-known representatives of this small division are the *Kiwis* of New

Zealand, Fig. 113, the *Rheas* or South American Ostriches, and the *Struthionies* or African Ostriches, Fig. 114, to be discussed later.

In the Carinatae are included the vast majority of modern birds. The division is named from the deep keel-like sternum possessed by most of them which possess the power of flight. While the ostriches owe their safety to their large size and powers of rapid terrestrial locomotion, and the kiwis to their isolation on the Island of New Zealand, the carinatae, which are usually of comparatively small size, owe their safety to their almost universally highly developed power of aerial flight. It is this power that also enables them to perform their annual migrations and thus better preserve their own lives and that of their young. This migration of birds is one of the most interesting subjects in the field of zoology and its bibliography is very extensive.

FIG. 113.—A kiwi, *Apteryx australis*. $\times \frac{1}{10}$. (From Hegner, College Zoology, after Evans.)

In a few of the Carinatae, the Penguins, for example, the wings are developed into paddle-like organs for swimming under water and the power of aerial flight is entirely lacking. A few of the countless species of birds of economic importance will now be discussed, most of which species will obviously belong to the division Carinatae.

The Ostrich.—Only the African ostrich, *Struthio camelus*, will be discussed here, since the Rheas or South American ostriches are of much less importance, though they are hunted by the natives almost to the point of extinction, their feathers being useful for dusters and other purposes. They are smaller than the African forms but have similar habits.

The African ostrich originally inhabited all of the more or less desert parts of the Dark Continent and certain regions of Southern Asia.

Authorities differ as to whether the different forms all belong to the same species or not.

FIG. 114.—African or two-toed ostrich, *Struthio camelus*. (Photograph by William Graham, from Jordan and Heath, *Animal Forms*.)

It is the largest living bird, sometimes reaching a height of 8 feet and weighing 300 pounds. The head and neck are nearly

and the legs quite naked. The body feathers are grey in the hen and black in the cock; those of the tail and abortive wings are the beautiful white plumes that have been prized as ornaments from the earliest times.

In their native haunts the ostriches live in flocks or, especially in the breeding season, small groups of one male and several females. These females all commonly lay in one nest or hole in the sand until 30 or more eggs are collected; the eggs are incubated partly by the heat of the sun, partly by the adult birds, especially the male. The eggs hatch in 6 or 8 weeks, the speckled young being as large, at hatching, as good-sized fowls.

The male acts as guardian to the flock and is said to be able to kill a man or even a horse with a forward or sidewise kick of its formidable two-toed foot. Under domestication they become gentle, but each ostrich farm is apt to have a big male that is said to be "very dangerous" and visitors are warned to keep at a safe distance; such an animal adds to the interest of the exhibit just as a "man-killer" lion does to a traveling circus.

They are, like most birds, very wary, which, added to their speed, which is said to exceed that of a swift horse, makes them difficult to capture. They are sometimes run down by a relay of horses, though their habit of running in a curve often makes it possible to cut across and head them off. Traps, pitfalls, lassoes, poisoned arrows and other methods were used by the natives to capture them. The old story of their sticking their heads in the sand and thinking themselves hidden is, of course, without foundation in observed fact.

While their natural food is largely vegetable they will eat practically anything, including small stones to aid the gizzard in grinding the food. A favorite pastime of visitors at some of the ostrich farms is to feed oranges to the birds, who swallow them whole with ease, and the course of the orange down the long œsophagus may be seen as a slowly moving swelling on the animal's slender neck. This habit of eating anything of suitable size for swallowing has doubtless been responsible for the exaggerated ideas of the ostrich's phenomenal powers of digestion. Though they can exist for long periods without water, they drink frequently when water is at hand and they are said to be fond of bathing up to the neck in water.

The flesh is but little used as food, but the eggs are often eaten,

one containing as much food as two dozen hens' eggs. The shells are used as vessels by the natives. It is chiefly for the plumes, however, that the ostriches have been hunted and have long been domesticated.

The oldest ostrich farms are probably those of South Africa, where there are now about half a million tame birds; the annual output of

FIG. 115.—Plucking an ostrich. Note the pen to confine the bird, and the hood over his head. (From Pickrell, *Ostrich Farming in Arizona*.)

these farms is said to be about \$10,000,000. The plumes from these domesticated birds are superior to those of the wild ones. A pair of tame birds is worth from \$700 to \$1000 and the net profits of the business in South Africa may reach 40 per cent.

Ostriches were introduced into the United States in 1882 and there are now farms in Florida, Arizona, California, and elsewhere. By charging an admission fee these farms produce a considerable income in addition to that from the plumes.

The birds are kept in fenced inclosures, usually in trios. The eggs are collected as laid and are hatched in mammoth incubators. About 35 young per year per trio are produced, though a record of 133 was made in South Africa. As noted above, the young are about the size of a hen when hatched, and in six months they have nearly reached the adult size; they are fed on chopped green alfalfa, and are given plenty of water. The adults eat any sort of vegetable matter. The plumes, which grow on the rudimentary wings and tail, are clipped or plucked, without pain to the birds, once or twice a year, Fig. 115. Fifty dollars worth of plumes may be obtained, in some cases, from one bird per year. The body plumes are attractive but have, of course, far less value than those from wings and tail. Plumes have been produced by well-cared-for individuals for 35 to 40 years.

One of the chief uses of birds has been, from ancient times, as food. Nearly all species, unfortunately, may be eaten, but the wild ducks and geese are particularly desirable, some species, like the canvas-back duck, bringing high prices. These aquatic forms have been able, by the aid of more or less efficient game laws, to survive the attacks of sportsmen and pot hunters, but some of our most valuable birds, the quail, grouse, etc., have been hunted, in many sections of the country, practically to the point of extermination, and should be protected by a closed season of indefinite length.

On some rocky coasts the eggs of sea birds were formerly found and collected in enormous numbers, until the birds were, in many cases nearly exterminated. Such was the case with the Murres of the Farallone Islands, off the coast of California. The eggs of these birds were formerly collected and sold in San Francisco by the hundreds of thousands. Jamaica is the centre of a small trade in "Booby eggs," laid by the Sooty Tern and the Noddy.

A classic illustration of the extinction of a race of animals by the utterly ruthless hunting of it for food is that of the wild or passenger pigeon. A generation or two ago these birds were found in the States west of the Alleghenies in numbers that surpassed belief. They flew in flocks that were numbered in the millions, yet, today there is not, so

far as is known, a single living passenger pigeon in existence. It seems probable that, with the death, within the last decade, of the single specimen in the Cincinnati zoological park, the species became extinct. They were hunted during the breeding season, just before the squabs were able to fly; men with their families, in wagons and other vehicles, came for miles to the woods where the nests were built to collect the young birds which were wonderfully fat. Trees were felled in such a way as to bring down others in their fall, and each tree was loaded with nests and young. The birds were packed in boxes, and barrels and shipped to the larger cities by the carload, sometimes spoiling on the way and having to be thrown out. It was this wholesale slaughter that totally exterminated a fine race of birds.

Another more unusual article of diet, derived from birds, is the edible bird's nest, especially esteemed by the wealthy Chinese, some of whom ascribe to it valuable tonic properties which it probably does not have. As is generally known these nests are built by swift-like birds (genus *Collocalia*) of the Orient in rocky caverns, usually along the sea, especially in the regions north of Borneo. The nest is of about the size and shape of that of the common chimney swift but consists of a more or less pure network of dried secretion of the salivary glands, looking and tasting like unflavored gelatin. The birds collect in the caverns, some of which are of great extent and beauty, in enormous numbers, and the natives here collect the nests by means of ladders and ropes, each man or group of men assuming hunting rights over certain caves and resenting the intrusion of other hunters upon their preserves.

The nests sell at \$12 to \$15 or more, per pound. The quality of the nest varies; the "white" or first quality nest consists of pure secretion; this nest being removed, the bird builds another, into which she may introduce some foreign matter to help out the diminished supply of saliva; this foreign matter, of course, detracts from the value of the nest; a third nest will have still more foreign matter, while the fourth may be so contaminated as to be worthless as food; it is probably this introduction of foreign matter into the nests that has saved the birds from extinction. The annual value of these nests in some of the small ports of the orient amounts to many thousands of dollars.

The nests are made into soups, jellies, etc. The author cooked a nest according to the only recipe available and found it very tasteless

and insipid; perhaps the Chinese, who are noted cooks, are able to give it a remarkably desirable flavor.

One of the most ancient and widespread uses to which birds are put is for the personal adornment of mankind. This largely useless and barbarous custom, thanks to the efforts of the Audubon Society and other organizations, is gradually disappearing among civilized peoples, so far as it necessitates the killing of birds for the sake of their plumage.

One of the best, or rather worst, illustrations of the lengths to which man will go along these lines is to be seen in the famous Bishop Museum in Honolulu, H. I. There are here to be seen the royal robes made of yellow feathers and said to be worth hundreds of thousands of dollars. The yellow feathers for these robes were obtained, it is said, from a small patch of yellow feathers on the breast of a bird about the size of a robin. The numbers of these small birds that must have been slaughtered to obtain the thousands of feathers in each of these gorgeous robes can be imagined, as each patch of yellow, so far as the writer can remember, was not greater in area than a square centimeter. The wearing of aigrets by women in the so-called "best society" was a custom hardly less barbarous, since, as is now generally known, these aigrets were the nuptial plumes of the white herons, Fig. 116, *Ardea egretta* and other species, to obtain which the adults were slaughtered during the breeding season, which often left the young to die of starvation after the parent birds were killed. These beautiful birds were once to be seen by the thousands, in the south, while now one may travel the swamps for days without seeing one. Fortunately the government has at last taken a hand in the protection of the egrets against this useless slaughter, and perhaps in time they may again become abundant.

Another group of beautiful birds that man formerly hunted most ruthlessly for their plumage are the Birds of Paradise. The natives of the Orient hunted them with blunt arrows, with snares, with bird-lime and in other ways, and civilized (?) man used his superior weapons to destroy, still more rapidly, these wonderfully beautiful creatures. Fortunately public sentiment and federal laws are now beginning to frown upon this kind of slaughter and perhaps the Paradise birds may be saved from the fate of the passenger pigeon.

An important avian product is guano, a most valuable fertilizer found on certain islands and coasts of the South Pacific, especially on the Chincha Islands, off the coast of Peru. This material consists of the

dried excrement of numberless sea birds (usually), deposited, during long ages in a practically rainless region. On the Chincha Islands the deposits were as much as 100 feet thick, but they have now been depleted.

These large fish-eating sea birds congregate at certain places in incredible numbers and with no rain to wash it away the excremental matter would collect indefinitely. The term *guano* is applied also to

FIG. 116.—American egret, *Ardea egretta*. Length, 41 inches. Photograph from specimen with neck extended. (From Daugherty, *Principles of Economic Zoology*.)

the collected excrement of bats, sometimes found in caves, and to fertilizers artificially made from certain fishes—menhaden for example—after extracting the oil.

A number of birds are of some importance as scavengers, though perhaps their usefulness in this particular way has been exaggerated. The

best known of our North American scavengers are the carrion crows, or black vultures and the turkey buzzards or vultures. The former, *Catharista atrata*, is the smaller of the two and is common in the vil-

FIG. 117.—California quail, *Lophortyx californicus*. $\times \frac{1}{3}$. (From Jordan and Heath, *Animal Forms*.)

lages and towns of the Southern States, especially along the coasts. It flies about the streets feeding upon refuse, and often becomes quite tame.

The turkey buzzard, *Cathartes aura*, whose majestic flight is familiar to most people in the rural sections of the United States has been con-

sidered of such value as a scavenger that it has been protected, by some States, by a fine for killing it. Of recent years, however, the opinion is held by many that the buzzards and perhaps crows are far more injurious than beneficial since they apparently are conveyors of the germs of hog cholera and possibly other diseases of domestic animals. It is possible, then, that a bounty rather than a fine should be placed on the head of the turkey buzzard. The way in which the buzzards locate an animal so shortly after its death has always been a mystery, some authors holding the birds are guided by a remarkably keen sense of smell, others that it is an equally remarkable sense of sight. It is usually thought that it is a matter of sight, and that when one bird locates the carcass and begins to investigate in smaller and smaller circles, the other birds, noting these actions, are attracted toward the same locality until often a considerable number will congregate to feed upon the carcass of a comparatively small animal; Chapman says both sight and smell are used.

In the far South the carrion crows and buzzards often congregate upon the trees under which hunters are skinning the alligators they have killed during the preceding night, and as soon as a carcass is thrown away the birds drop to the ground and begin to tear at the flesh and viscera. The writer once made use of such a flock of birds to "rough up" the skeleton of a 6-foot alligator. After removing the skin and the viscera the body was thrown on the grass just outside of the camp; in a few hours the birds had picked off the meat so nicely that the skeleton had simply to be rubbed over with salt (NaCl) to make it fit to be shipped home as a "rough skeleton" ready for the taxidermist.

On the Pacific coast the California vulture or "Condor," *Gymnogyps californianus*, is found in very small numbers. It is a magnificent bird with a spread of wings of from 8 to 11 feet, and is rigidly protected by law.

The relation of birds to agriculture is an extensive subject in itself and it can be merely touched upon here, along some of its more important lines.

There are two ways in which birds are of especial benefit to agriculture: as destroyers of insects and as eaters of weed seeds. The former is universally recognized; the latter is not so generally appreciated. A great deal of investigation has been carried on, during recent

years, upon the food of our common birds. In determining the economic status of any bird it is necessary to know of what its food consists at all seasons of the year. A bird may be a nuisance for a few weeks, as a fruit eater, for example, while all the rest of the year it may be highly beneficial to the farmer as an eater of weed seeds and of destructive insects.

The food of birds is determined in two ways: the more pleasant but less accurate method is to watch them feed and note what they eat; the less pleasant but more accurate method is to kill the birds at dif-

FIG. 118.—The hairy woodpecker, *Dryobates villosus*, at breakfast. $\times \frac{1}{3}$. (From Daugherty, *Principles of Economic Zoology*, after Biological Survey, U. S. Dept. of Agriculture.)

ferent seasons and in different places and examine carefully the stomach contents. The latter method, which has been extensively employed by the Biological Survey of the Department of Agriculture, gives not only the kinds of foods eaten but the proportions of each kind. By such studies it has been determined that while few species of birds, perhaps, are *entirely* beneficial, the vast majority of our common birds do far

more good than harm and should, therefore, for purely economic reasons be protected. In a few cases the good and bad traits are so equally balanced that it is difficult to decide upon the economic status of the species; and in still fewer cases the bad traits clearly overbalance the good ones and the species are rated as pests.

Another way in which birds are of great benefit to agriculture, and one that needs emphasizing more than the others, is in the destruction of field mice and other rodent pests, to be discussed later. The birds that do this valuable work are the various species of hawks and owls. The latter being nocturnal are more or less free from the danger of man's firearms; but the former are almost universally considered, by farmers and others to be pests, since some of them, at times, do destroy young poultry and beneficial birds. The owls being nocturnal are especially adapted to feed on rodents which are also largely nocturnal in habits, and with the possible exception of the Great Horned Owl, they are all considered to be beneficial birds.

The Great Horned Owl, *Bubo virginianus*, Fig. 119, is a large species, nearly 2 feet long, with prominent ear-tufts that give the appearance of horns; it lives in less populous regions and destroys poultry and birds in considerable numbers, but often counterbalances this damage by the destruction of rabbits that, in many places, are a pest, as will be noted later.

Fisher (143) found that, "Of 127 stomachs (of the owl) examined, 31 contained poultry or game birds; 8, other birds; 13, mice; 65, other mammals; 1, a scorpion; 1, a fish; 10, insects; and 17 were empty." It will be seen that of these stomachs only 39 contained birds while 78

FIG. 119.—Great horned owl, *Bubo virginianus*. $\times \frac{1}{6}$.

contained mammals and 10, insects; surely the balance here seemed to be in the owl's favor.

The Barn Owl, *Strix pratincola*, Fig. 120, the Screech Owl, *Megascops asio*, and some others are specially useful species.

As a general proposition, then, the owls should by all means be protected and encouraged in every way.

FIG. 120.—Barn owl, *Strix pratincola*. $\times \frac{1}{5}$. Photograph from specimen. (From Daugherty, *Principles of Economic Zoology*.)

try; the American Goshawk, *A. atricapillus*, is a still larger species breeding north of the United States and wintering as far south as Virginia.

The hawks most commonly known as Hen Hawks or Chicken Hawks are the Red-tailed, *Buteo borealis*, and the Red-shouldered, *B. lineatus*. These large hawks, common in Eastern North America, are generally blamed for the loss of poultry really due to Cooper's Hawk or one of the other species. In studying the food of hawks, Fisher found in connec-

The record of the hawks, while not so good as that of the owls, is far better than is popularly supposed. They, too, live largely upon rodent pests and a few of them also destroy poultry and beneficial birds.

The hawk-like birds that are considered by ornithologists to be more destructive than beneficial are as follows: the Gyrfalcons (genus *Falco*) which are essentially arctic forms; the Duck Hawk, *Falco peregrinus anatum*, ranging over North America, especially near water, where it is destructive to water fowl; the Sharp-shinned Hawk, *Accipiter velox*, breeding throughout the United States and destroying birds and poultry; Cooper's Hawk, *A. cooperi*, Fig. 121, similar to but larger than the Sharp-shinned and especially destructive to poultry;

tion with the Red-tailed Hawk that "Of 562 stomachs examined, 54 contained poultry or game birds; 51, other birds; 278, mice; 131, other mammals; 37, batrachians or reptiles; 47, insects; 8, crawfish; 1, centipede; 13, offal; and 89 were empty." It will be noted that 456 stomachs of the 562 examined contained mammals and insects, so that this much-maligned bird evidently does much more good than harm, in spite of its occasional theft of small poultry.

FIG. 121.—Cooper's hawk, *Accipiter cooperi*. $\times \frac{1}{5}$.

Since so very few people are able to recognize the few destructive species of hawks, especially on the wing, it would seem much the better plan to "play safe" and leave them all alone.

As an illustration of the losses sometimes caused by ignorance of the real habits of animals, especially birds, Chapman (139) quotes as follows from the 1886 report of C. Hart Merriam, then Ornithologist and Mammalogist of the United States Department of Agriculture:

"On the 23d of June, 1885, the Legislature of Pennsylvania passed an act known as the 'scalp act,' ostensibly 'for the benefit of agriculture,' which provides a bounty of 50 cents each on hawks, owls, weasels and minks killed within the limits of the State, and a fee of 20 cents to the notary or justice taking the affidavit.

"By virure of this act about \$90,000. has been paid in bounties during the year and a half that has elapsed since the law went into effect. This represents the destruction of at least 128,571 of the above-mentioned animals, most of which were hawks and owls.

"Granting that 5000 chickens are killed annually in Pennsylvania by hawks and owls, and that they are worth 25 cents each (a liberal estimate in view of the fact that a large proportion of them are killed when very young), the total loss would be \$1250, and the poultry killed in a year and a half would be worth \$1875. Hence it appears that during the past eighteen months the State of Pennsylvania has expended \$90,000 to save farmers a loss of \$1875. But this estimate by no means represents the actual loss to the farmer and the tax-payer of the State. It is within the bounds to say that in the course of a year every hawk and owl destroys at least a thousand mice or their equivalent in insects, and that each mouse or its equivalent so destroyed would cause the farmer a loss of two cents per annum. Therefore, omitting all reference to the enormous increase in the numbers of these noxious animals when Nature's means of holding them in check has been removed, the lowest possible estimate of the value to the farmer of each hawk and owl would be \$20 a year, or \$30 in a year and a half.

"Hence in addition to the \$90,000 actually expended by the State in destroying 128,571 of its benefactors, it has incurred a loss to its agricultural interests of at least \$3,857,130, or a total loss of \$3,947,130 in a year and a half, which is at the rate of \$2,631,420 per annum. In other words the State has thrown away \$2,105 for every dollar saved. And even this does not represent fairly the full loss, for the slaughter of such a vast number of predaceous birds and mammals is almost certain to be followed by a corresponding increase in the number of mice and insects formerly held in check by them, and it will take many years to restore the balance thus blindly destroyed through ignorance of the economic relations of our common birds and mammals." Fortunately this law was soon repealed.

As noted above there are a few birds which do more harm than good and a few whose economic value has not been definitely determined. As an example of the former group the English Sparrow stands out. Introduced into this country first at Brooklyn, N. Y., in 1850, and later into various States, the House Sparrow, popularly named from the country whence it was brought, has spread over practically the entire country and parts of Canada. It is supposed to have been introduced for two main reasons: to destroy certain insects then damaging crops and for sentimental reasons by persons of foreign birth who wanted to

see a familiar European bird in this country. Its introduction into America is an excellent illustration of the danger of introducing an animal into a new environment which may prove so favorable that the animal will increase in numbers to the extent of being a pest. This is exactly what has happened in the case of the English Sparrow, which is considered such a pest that various methods of extermination have been suggested and, usually, unsuccessfully tried. What will be the final outcome it is difficult to foresee. It is claimed by some that 98 per cent. of the food of this sparrow is vegetable and that 74 per cent. is grain. It also damages fruits and young flower buds. It is pugnacious and quarrelsome and by occupying the available nesting places tends to drive away other small, valuable birds. It has a tendency to live about houses which it often soils in a very annoying way. It is of some slight value about towns as a scavenger and possibly does some good as a destroyer of insects and weed seeds, but the total balance seems to be strongly against it. As the writer knows from personal experience it may be kept away from individual homes in the country by a ceaseless warfare, killing the adults with a .22 calibre rifle, using shot cartridges, and destroying the nests as fast as built.

The American crow, *Corvus americanus*, one of the most familiar of all our birds, is very generally considered by farmers to be a pest because of its habit of eating newly planted corn and other grain, not to mention eggs and small chickens; but it is not at all certain that it does not much more than pay for this loss in the insects and other pests that it destroys, throughout the year, which are said to constitute more than 23 per cent. of his diet. By most people the common or American crow is not distinguished from the considerably larger species of the same genus, the northern raven, nor from the somewhat smaller species the fish crow.

The jays, especially the common blue jay, *Cyanocitta cristata*, are another group of familiar birds whose economic value is very doubtful on account of their habit of destroying the eggs and young of other birds; but along with these highly undesirable habits, they have others that are of benefit to man.

In some sections the blackbirds or grackles (genus *Quiscalus*) are considered a pest because of the damage they do to ripening corn, late in the summer; it is probable again that this damage is more than

atoned for by the insects and weed seeds destroyed during the rest of the year.

There is one way in which our winter birds do a wonderfully important work; it is in the destruction of great numbers of insect larvæ

FIG. 122.—Four common seed-destroying sparrows: 1, Junco; 2, white-throated sparrow; 3, fox sparrow; 4, tree sparrow. (From Daugherty, *Principles of Economic Zoology*, after Bulletin 17, *Biological Survey*, U. S. Dept. of Agriculture.)

that are hidden under the bark of trees and in all sorts of out-of-the-way places. During the cold months when adult insects are lacking

and vegetable food is scarce our winter residents fairly comb the trees for these wintering larvæ, which must be carefully hidden to escape the sharp eyes of the hungry birds.

It is obvious then that every means should be employed to protect and encourage our native birds, and some of the ways in which this may be done will be briefly described. Two main lines may be followed in bird preservation; (1) control of bird enemies and (2) direct protection and encouragement of the birds themselves.

According to Forbush the numbers of birds in Pennsylvania decreased over 50 per cent. in 15 years; this decrease was due largely, though not entirely, to their destruction by their enemies, chief of whom is man. Man, the worst enemy of all living things, has killed birds by the million, for food, for plumage and for mere wanton sport. Man also includes the small boy, and the boy that is not so small, who not only kills birds with guns and other weapons but who also robs the nests, in the collection of bird eggs, a habit that should be discouraged in every possible way. Perhaps the worst offenders against the bird life of the country are the foreign laborers, who slaughter indiscriminately every bird, large and small, that comes within range. Vigorous laws against hunting on Sundays have helped diminish this nuisance, and other game laws, to be discussed later, have done much to save many species from extinction. Man has also done much, unintentionally, to diminish the bird population by clearing woodlands and thickets, draining swamps, etc.

Of the so-called natural enemies of birds the house cat is probably the most destructive, especially the half-wild kind that is seen about every farm, village and city. It is estimated that cats kill, on an average, from 10 to 50 birds each year; if only 10 per year are killed the total for the State of Massachusetts would probably be about 700,000. Another estimate gives the total birds killed by cats at 31,000,000 per year. Whatever the number may be it is probable that cats destroy more birds than all the other animals (excluding man) combined. Although of value as destroyers of rats and mice, in some cases, as will be noted later, it is probable that the country would be better off if the race of domestic cats were exterminated. Many a farmer that will kill a cat for catching a very occasional small chicken seems to pay no heed whatever to the continual destruction of birds, by the dozen or more cats about the place.

Dogs, foxes, minks, etc., destroy some birds, but probably not to a very serious extent; the value of the latter two as rodent destroyers will be discussed later. Some squirrels, especially the red squirrel, destroy considerable numbers of eggs and young birds, but since they also eat insects their economic status is perhaps uncertain.

Rats and mice do some damage, especially to birds nesting on the ground and about human habitations. Hawks, especially Cooper's and the sharp-shinned varieties, destroy many birds and if recognized as belonging to these destructive species they should be killed. Owls kill some birds, but, as already pointed out, most of them are so valuable as destroyers of rodents that they more than pay for the birds they destroy.

Crows, jays and shrikes sometimes do considerable damage to the eggs and young of other birds; and one who has seen a shrike empale a sparrow or some other small bird on a thorn and then deliberately tear it to pieces and eat it will not have much love for the butcher bird.

Certain snakes are accused of eating birds and bird eggs, but, like the owls, it is probable that most species more than make up for the birds eaten by the destruction of rodent and other animal pests.

It is seen, then, that the two worst enemies of birds are man and the domestic cat, both of whom could and should be controlled, the former by law, the latter by a marked reduction in numbers if not by extermination.

Encouragement of Birds.—To encourage birds and thereby increase their numbers a number of things may be done, some of which will be briefly noted: 1. Forbid their being shot, both in season and out, by adults and by boys, and especially by ignorant foreigners and negroes. Aid in the passage of suitable laws for the protection of all sorts of game, especially birds. Although largely through selfish motives, the sportsmen of the country long ago saw the necessity of protecting game birds, and as early as 1791 New York enacted a law protecting certain game birds. Only recently have the farmers begun to see the necessity of stringent game laws to protect birds, and now we not only have state laws but we are beginning to have federal laws, like the McLean Migratory Bird Law that protects migratory birds wherever found, with the idea that a bird that moves from one part of the country to another belongs to the country as a whole and not to any one state where it may

spend a few weeks or months each year. The passage of this law was one of the greatest advances of the age in bird protection. Before its

FIG. 123.

FIG. 123.—Bird house made from hollow log. $\times \frac{1}{8}$. (From Dearborn, [Bird Houses and How to Build Them.]

FIG. 124.

FIG. 124.—Gourd for wrens or bluebirds. $\times \frac{1}{8}$. (From Dearborn, Bird Houses and How to Build Them.)

passage a reed bird, for example, might have been protected in Virginia, but as soon as it crossed the North Carolina boundary it could be slaughtered in any numbers.

By a treaty with Canada, effective July 31, 1918, migratory birds are given not only national, but international protection. The various regulations of this treaty define the means by which migratory game birds may be taken, the open season for certain birds, bag limits, etc.

The killing at any time in the United States of the following birds is forbidden by law: band-tailed pigeon, common ground doves and scaled doves, little brown crane, sandhill crane, whooping crane, wood duck, swans, curlews, willet, upland plover, all shore birds (except black-bellied and golden plovers, Wilson snipe or jacksnipe, woodcock, and the greater and lesser yellow-legs), bobolinks, catbirds, chickadees, cuckoos, flickers, flycatchers,

FIG. 125.—Tomato can, with one end removed, fastened to top of post. Hole cut in side for entrance. Suitable for bluebirds or wrens if put in shady place. (From Dearborn, Bird Houses and How to Build Them.)

grossbeaks, humming birds, kinglets, martins, meadow larks, night hawks or bull-bats, nuthatches, orioles, robins, shrikes, swallows, swifts, tanagers, titmice, thrushes, vireos, warblers, waxwings, whip-poor-wills, woodpeckers, wrens, all other perching birds which feed entirely or chiefly on insects; also auks, auklets, bitterns, fulmars, gannets, grebs, guillemots, gulls, herons, jaegers, loons, murre, petrels, puffins, shearwaters and terns.

The various states have game laws of various degrees of stringency for the protection of their local resident birds, that is, the birds that do not migrate and hence do not receive protection under the McLean law. For example there is generally a closed season during which these birds cannot be killed; often a limit is set upon the number of birds that may be killed in one day and in an entire season; a license, either free or to be bought, is often required for each hunter; unnaturalized foreigners and minors under a certain age are sometimes forbidden to hunt; hunting on Sundays is sometimes forbidden; occasionally an animal becomes so scarce that a closed season for a term of years is declared, thus giving the species a chance to recuperate if, as may happen, the closed season has not been too long delayed. There are many birds that should be thus given a chance to recuperate by a long if not perpetual closed season; for example, the quail one of our most useful insect and weed destroyers, should, in many states, doubtless be given a long if not a permanent protection against sportsmen.

2. Destroy useless cats and dogs, especially in small towns and in the country; the destructiveness of cats has already been noted, their claims to usefulness will be discussed later.

3. Discourage the use of bird ornaments; this is largely accomplished now by federal laws that absolutely protect certain birds by making the possession of their plumes a felony.

4. Organize Audubon and other societies to excite popular interest in birds and to offer possible aid in securing suitable legislation.

5. Stop the collection of bird eggs by youthful or even older collectors, unless for some well-established scientific institution.

6. Educate the public, especially the children who will be the hunters of the future, by lectures, bird-days in schools, etc. It is here that the teachers in secondary schools can and do accomplish a great work, by bringing up the next generation to be lovers and students, rather than hunters of birds.

7. Preserve old trees, posts, and an occasional thicket in which birds are in the habit of nesting, and erect boxes and other nesting devices for them in suitable places. The character of the boxes will vary with the birds that it is desired to attract, and their architecture may be infinitely varied. Old tin cans, hollow logs, gourds, etc., may be easily made over to suit bird tenants, Fig. 123, 124 and 125, or if more ornamental structures are desired, the birds will not object after the paint is dry and the newness has worn off. Plans for bird houses are given in various government bulletins and elsewhere. Unless it is desired

FIG. 126.—A martin house. $\times \frac{1}{10}$. (From Dearborn, *Bird Houses and How to Build Them*. This pamphlet gives details of construction.)

to attract martins, the only house birds that are social, the houses are built for one pair only.

In many localities it is quite a common custom to build many-roomed and often ornate houses for the use of the purple martin, *Progne subis*. Such houses, Fig. 126, are usually attached to the top of a pole, 12 to 15 feet high; the rooms are about $6 \times 6 \times 6$ inches in size. With such a house a colony of martins may sometimes be started from an overcrowded colony several miles away. They are not only cheerful,

interesting birds, but they are extremely useful as destroyers of insects which they capture on the wing.

8. Supply food, especially in the winter; and nesting material, water, etc., in the summer. To protect the birds while feeding or to keep the food from being covered with snow, various kinds of platforms and food houses have been constructed usually with the idea of

FIG. 127.—Food shelf outside of window, so arranged that birds may be watched from the room within. (From McAtee, *How to Attract Birds in Northwestern United States*.)

allowing the birds to be seen while feeding, Fig. 127, 128, 129 and 130. Where water is scarce mud may be provided for the use of robins and other birds that use it in building their nests.

Where birds that are otherwise useful are destructive to small fruits and berries they may be attracted away from these fruits by planting about the orchard, for their especial use, various wild or uncultivated

species such as the mulberry, service berry, Virginia creeper, elderberry, holly, various wild grapes, etc.

Some of the above methods of encouraging bird life are more important than others and their importance will vary in different localities, but all will help, more or less, to increase the numbers of this most useful and attractive group of animals.

Another method of encouraging bird life which is of very great importance, but which only a few people are financially able to indulge

FIG. 128.—A feeding box attached to the top of a pole. It is open at the bottom but has glass sides and a tight roof. (From McAtee, *How to Attract Birds in Northwestern United States*.)

in, is the establishment of bird preserves. To be sure every farmer who absolutely forbids the killing of birds on his farm is maintaining a small and useful bird preserve; but there are being established, from time to time, large tracts of land for this purpose whose value to the bird life of the country is incalculable. An example of such a preserve is Marsh Island, near New Orleans. This is a tract of some 75,000 acres, purchased by Mrs. Russell Sage and given by her to the United States as a refuge for birds during their stay in the south in the winter or through-

out the year. In this reservation where formerly the birds were slaughtered by the thousands by pot-hunters and sportsmen there is now a safe refuge where the native birds may rear their young and where the migrants from the North may safely spend the winter.

In conclusion, let every intelligent person use his influence in all possible ways to protect the birds. Public sentiment is fast tending

FIG. 129.

FIG. 129.—A feeding box pivoted on a pole so that the open side will be away from the direction of the wind. (From McAtee, *How to Attract Birds in Northwestern United States*.)

FIG. 130.

FIG. 130.—Food tray made from a barrel top and hoops fastened to top of pole. (From McAtee, *How to Attract Birds in Northwestern United States*.)

in this direction and there is yet time to prevent the almost total extinction of song birds that has taken place in some countries. By properly educating the coming generation it should be possible to produce a public frame of mind that would consider the unnecessary slaughter of birds as the real crime that it is.

CHAPTER XIV

MAMMALIA

Of all the classes of the animal kingdom the mammals are the highest, using that term in a broad sense, since it includes man, whose high mental development has given him dominion over the rest of the animate world. Economically it is doubtless the most important class of animals since it includes, among others, our domestic quadrupeds.

The name mammal has been derived from the presence, in all members of the class, of milk-secreting glands or mammæ for the nourishment of the young; these glands vary in development from the rudimentary organs of the Monotremes to the enormous udders of high-grade milk cows.

The other chief characteristic of the class is the presence, at some period of life, of hairs, which are almost as characteristic of mammals as feathers are of birds; these hairs vary from the soft fur of moles or seals to the long quills of the porcupine; like feathers they are of epidermal origin and like them also they are, in many cases, periodically shed and replaced.

Other epidermal structures are often highly developed, such as claws, hoofs and teeth, the last-named being almost universally present and in two sets, the "milk" and "permanent" teeth. The variation in bodily size among the Mammalia is enormous, extending from the tiny mice and shrews, 2 or 3 inches long to the largest whales, which may reach a length of 80 feet or more and are probably the bulkiest animals the world has ever produced, though not the longest.

With very few exceptions the ovum of mammals is of microscopic size and is developed within the uterus of the parents, to which it is attached and from which it derives its nourishment by means of a vascular structure the placenta.

Unlike the birds but few mammals migrate, but a number of them

hibernate in a dormant condition in some hidden place and thus pass the cold, foodless season, their warm blood and covering of hair protecting them against the cold. The red blood corpuscles of almost all mammals are circular discs, without nuclei. In all but two or three small groups all mammals have seven cervical vertebræ.

The number of known species of living mammals is variously stated. Henshaw, in 1912, estimated the number at 7000; other authorities place the number even higher.

The classification of the Mammalia, unlike that of the birds is pretty well established. By most authors they are divided into two subclasses: (1) Prototheria or egg-laying mammals and (2) Eutheria or viviparous mammals.

Under the first subclass is included but one order, the Monotremata; under the second subclass fall all the higher mammals including, of course, man.

As has been said this is economically the most important of all the groups of animals, though there is very great variation in the relative importance of the orders. These orders will now be taken up in turn but not in order of their economic importance.

Monotremata. Duckbill and Spiny Anteater.—These animals are commonly known as the egg-laying mammals from the fact that they lay eggs like those of birds and reptiles, the young being nourished by the yolk of the egg instead of through the placenta, as in other mammals. They are small animals, 18 to 24 inches in length, found only in the region of Australia and New Zealand. Their name is derived from the fact that the urogenital organs and intestine open into one cavity, the cloaca, as in birds and reptiles; they have other reptilian characteristics, also. The presence of hair and rudimentary mammary glands causes them to be classed as mammals. The two best known species of this small order are the duckbill or platypus, *Ornithorhynchus*, and the spiny ant-eater, *Echidna*. These forms, though most interesting zoologically, have but little economic importance. The former doubtless is of value as an insect eater, the latter is used for food to some extent.

Marsupialia. Kangaroos and Opossums.—The chief characteristic of this order and the one from which the name is derived is the possession of a marsupium or pouch of skin on the ventral abdominal wall; in this pouch the young, which are born in a very immature

condition, are placed by the parent, and they remain there, attached to the mammary glands, until more fully developed.

The best known representatives of this rather small group are the opossums, Fig. 131, of America and the kangaroos and wallabies of Australia, Fig. 132.

The Virginia opossum, *Didelphis virginiana*, is common in the southern and middle states. It is a grey, thick-bodied animal of about the size of a large cat; it has a rat-like, but prehensile, tail. It is

FIG. 131.—The opossum, *Didelphis virginiana*. $\times \frac{1}{16}$. (From Hegner, College Zoology.)

frequently hunted and used as food, the flesh being of a very agreeable taste. Its flesh is supposed to be especially popular with the negroes.

The kangaroos and wallabies vary in size from that of a small cat to 5 feet or more in height. Their small anterior legs are used as hands and the animals usually progress by a series of leaps, using for this purpose the strong hind legs and large tail. There are about 60 species of these Australian forms.

The kangaroos are vegetarians and at times may be injurious to

grass intended for feeding cattle. They are extensively hunted both for their hides, from which leather is made, and for their flesh which is excellent, especially that of the hind legs and tail. A large specimen may weigh 200 pounds. The flesh is said to resemble venison. As is

FIG. 132.—Kangaroo, *Macropus robustus*. $\times \frac{1}{10}$.

so often the case the animals are being hunted almost to extermination in many places.

Insectivora. Moles and Shrews.—This is a group of small mammals usually with soft hair or fur. Their projecting front teeth and sharp-pointed back teeth enable them to seize and eat insects

upon which they chiefly live. They are the most primitive of the placental animals. They are absent from Australia and from most of South America. They are mostly terrestrial and nocturnal in habits; many are subterranean; some are aquatic and some arboreal. The two North American families are the *Talpidae*, the moles, and the *Soricidae*, the shrews. The common mole, *Scalopus aquaticus*, Fig. 133, is the familiar, soft-furred animal, about 6 inches long, without external ears, with rudimentary eyes, and with huge hand-like front feet that it uses in burrowing just beneath the surface of the ground. This is one of the most useful and least appreciated of our common animals. On closely trimmed lawns it sometimes makes a nuisance of itself by up-

FIG. 133.—Common mole, *Scalopus aquaticus*. $\times \frac{3}{4}$. (Courtesy of the Biological Survey.)

heaving the sod above its tunnels, but in the fields and gardens it does an immense amount of good by eating cut-worms and other insects destructive to vegetation.

It is almost universally considered by farmers to be destructive to vegetation because its burrows are not distinguished from those of that most destructive rodent, known as the Pine Mouse, to be discussed later. It should be remembered that this mole is an *insect-eating* not a *plant-eating* animal and it should not be blamed for the destruction of young plants, newly planted corn, potatoes, etc., which are often seriously damaged by field mice.

The shrews are much less well known than the moles. They are small mouse-like animals with long, pointed snouts. Some of them

are the smallest of all mammals. They usually live on the ground or in holes and are easily mistaken for mice. While their habits are not very well known they are doubtless valuable insect destroyers.

Moles are sometimes used as food, but their small size and comparatively small numbers makes them of no importance in this way.

Hedgehogs are sometimes used as food. They may be covered with a layer of clay, which peels off, when the animal is removed from the fire, bringing the spines of the animal with it. The hedgehog is not found in North America.

Chiroptera. Bats.—The bats are at once recognized by their large membranous wings, the digits of the fore-legs being enormously elongated and connected by thin membranes of skin. Their power of flight has caused them to be widely distributed, often in places inaccessible to other mammals. There are more than 600 species of bats, varying from a few inches in expanse of wings to 5 feet, in the “flying

FIG. 134.—Little brown bat, *Myotis lucifugus* (*Vespertilio subulatus*) $\times \frac{1}{2}$.

foxes” of the Orient. They are usually nocturnal and spend the day hanging head-down in some cave or other dark place. In certain limestone caves they may be found hibernating in enormous numbers. They fly through the intricate and totally dark passages of these caverns with perfect ease and certainty, owing to the possession of a certain marvelously acute tactile sense that warns them of their near approach to solid bodies.

A few large oriental and other tropical bats are fruit-eaters and are quite destructive to figs and other tropical fruits, especially since they often travel about in groups.

Most bats, however, are insectivorous, and, being nocturnal in habits, destroy many forms that would not ordinarily fall prey to birds. It is

evident, then, that our ordinary bats should not be molested but should be encouraged. The experiment has been tried of furnishing them with artificial shelters in which to spend the day, hoping in this way to encourage them to remain in a given locality.

Among the commoner bats of the United States are the Little Brown Bat, *Myotis lucifugus*, Fig. 134, the Red Bat, *Lasiurus (Atalapha) noveboracensis*, each about $3\frac{1}{2}$ inches long and the Brown Bat, *Eptesicus fuscus*, a slightly larger form.

In some way two statements about the common bats have become current; first, that they often entangle themselves in women's hair, and second, that they bring bedbugs into houses. I have questioned many men and women and have not found a single one who ever *knew* of a specific case where a bat had become entangled in human hair. I have also examined many bats, on one or two occasions, in the caves where they were hibernating by the thousand, but *never* was a bedbug and seldom was any kind of a parasite seen. They are not very attractive little animals, since they bite quite vigorously and often have an unpleasant animal odor, but they are quite inoffensive if unmolested and are, as has been said, highly beneficial as insect destroyers.

In the regions where they abound, the large fruit-eating bats are sometimes killed for their skins which are covered with soft fur.

The *Vampire Bats* are inhabitants of South America; they injure horses and cattle and other animals, especially the young, by sucking their blood. It is *reported* that they may even attack a sleeping human being, fanning him with their wings to insure sound slumbers, while they puncture the skin of the victim's foot with their sharp front teeth and then suck or lap the blood. The author does not vouch for this story, however, especially the part about fanning the sleeper with their wings. Beebe,¹ tells of sleeping in Guiana with Vampires flying in the room without being molested; but White¹ reports being bitten on the foot, while sleeping, by one of these bats, and advises sleeping under nets.

Carnivora. Flesh-eating Mammals.—While most of the carnivora, as the name would indicate, are flesh-eaters, some are omnivorous and a few are vegetarians. The teeth of this order form the most marked characteristic of this group. The incisors are usually small and weak; the canines, or "eyeteeth," on the contrary, are long,

¹ Tropical Wild Life in British Guiana. N. Y. Zool. Society, 1917.

sharp and curved, and aid their possessor in seizing and holding his struggling prey; the premolars and molars are adapted for cutting and grinding flesh, so that by means of these teeth a cat may be able to chew a tough piece of meat that a human being could scarcely eat at all. Most of the carnivora, at least of the terrestrial forms, have sharp claws that aid in the capture of food and in self-defense; the canine teeth also are, of course, important weapons of offense and defense. The carnivora include most of our so-called "fur-bearing" animals.

The dozen or more families of this order are usually grouped into two sub-orders: the *Fissipedia* or Carnivora Vera, including a large number of forms that are chiefly terrestrial; and the *Pinnipedia*, a much smaller group of aquatic forms, such as the seal, sea-lion, walrus, etc., to be discussed later.

The families of Fissipedia occurring in the Western Hemisphere, north of Mexico, with the approximate number of species of each (according to Hornaday) are as follows:

Canidæ (dog, fox, wolf, etc.).....	22
Felidæ (cats).....	8
Ursidæ (bears).....	12
Mustelidæ (marten, mink skunk, etc.).....	46
Procyonidæ (raccoon).....	3

The economic value of the Carnivora is chiefly due to their soft hair or fur, though there are other ways in which they have considerable economic importance, for example in the destruction of cattle.

According to the Biological Survey there is an annual loss of more than \$20,000,000 due to the destruction of livestock, chiefly on the western ranges, by wolves, coyotes, mountain lions and other predatory animals.

The Government, in coöperation with the states, is conducting a great campaign against these and other animal pests, in which probably more than \$1,000,000 annually is being expended.

Predatory animals are destroyed by poisoning, trapping, shooting and den hunting during the breeding season. In this work from 250 to 350 hunters are employed under district inspectors; about one-fifth of these hunters are paid by the states or by local organizations and individuals. The skins taken by Federal hunters become the property of the Government, with a total value during the last year of probably \$100,000.

Canada may, perhaps, be said to owe her start, commercially, to the fur trade. In the early days there was almost no limit to the profits of the fur business, since the Indians from whom they were chiefly obtained, did not appreciate the value of the skins they sold, and the early traders, "coureurs des bois," became a most unscrupulous and disreputable class of men. In 1670 the Hudson Bay Company was chartered, with extensive and exclusive privileges, and the sign of this company is still a familiar sight along the Canadian Pacific Railroad, though it is, of course, not merely a firm for handling furs. Since the fur-bearing animals are apt to be inhabitants of colder regions, many, if not the majority, of them are captured in Canada and the Northern States of the Union, though there are some valuable forms taken in the Southern States.

The American furs are usually superior to the European and millions of dollars worth are exported each year, while large numbers are imported into the United States.

"In the fiscal year ending June 30, 1917, the foreign trade of the United States in raw and manufactured furs reached nearly, if not fully, the high level of the years preceding the war. The imports were valued at \$21,553,375, while the exports amounted to \$15,729,160, a sum exceeded in only one previous year, 1913, when they were \$18,389,586" (1916).

While it is difficult to obtain accurate figures on the number of skins handled each year, the following quotation from a personal letter from Mr. E. W. Nelson, Chief of the Bureau of Biological Survey, will give an idea of the number and value of some American forms:

"Funsten Bros. of St. Louis, Mo., offered at their three auction sales during 1917, 5,345,000 American skins. At the March and October auction sales of the New York Fur Auction Sales Corporation, 2,152,900 American skins were offered. Whether these skins, nearly 8,000,000, were all taken in 1917 is not known. Probably they were not, but a large proportion of American skins do not pass through these two channels. At Funsten's three 1917 sales there were offered 3,110,000 muskrat skins which brought from \$0.06 to \$0.91 each; 586,000 opossum skins, which brought from \$0.01 to \$1.18 each; 446,000 skunk skins which brought from \$0.10 to \$4.35; 314,000 raccoon skins, which brought from \$0.35 to \$7.00 each; 186,000 ermine skins, which brought from \$0.10 to \$2.75 each; 155,000 mink skins, which brought from \$0.20 to \$11.50; 42,000 lynx skins which brought from \$1.00 to \$26.50 each; 37,955 beaver skins, which brought from \$1.25 to \$15.25 each; and 33,050 red fox skins, which brought from \$1.75 to \$33.50 each."

The frequent changes in fashion that cause wide fluctuations in market prices are probably the salvation of many species of fur-bearing animals by giving them a chance to recuperate during the periods when their hides are not in demand.

The preparation of most skins for shipment is easy; they are simply cleaned of fat and meat and are dried in a cool place.

Fur Farming.—It is probable that almost any of the fur-bearing animals may be profitably raised in captivity; as a matter of fact a number of them, the fox, skunk, muskrat, and others, are already so raised, the colder latitude of Canada, especially along the coasts, being the most suitable region for many of them. The necessary conditions, of course, vary with the species, and the habits of the animals to be handled must be carefully studied. There are several reasons for encouraging the domestication of the fur-bearing animals besides merely as a profitable venture.

In the first place unless they be so raised many of them will doubtless become extinct. Again the old methods of the trapper were very wasteful, many pelts being damaged by the traps and by larger carnivorous animals that fed on the smaller ones caught by the traps; these methods were wasteful also in catching and killing many animals whose fur was not in good condition. Lastly—

“Apart from economic considerations the cruelty involved in trapping wild animals affords a powerful argument against the continuation of the practice. Trapping is notoriously cruel and tends to destroy the finer feelings of those engaged in the business.

“Trappers visit their lines only two or three times a week, and in the interval the captured animals, in most cases suffering excruciating pain, are exposed to frost, hunger, their natural enemies, and finally, their arch-enemy—man . . . When it is remembered that millions of animals are captured yearly in traps the sum total of their suffering must be so great that the cruelty practised on dumb domestic animals, which so greatly concerns the Society for the Prevention of Cruelty to Animals, must seem slight in comparison. The methods of killing domestic animals are humane and painless, and it would seem that humane considerations alone present a sufficient argument for the domestication of fur-bearing animals (162).”

According to Jones the first fur-bearing animals to be raised under domestication were the various *Karakul sheep*, Fig. 135, whose lambs, for a few weeks (during which time they are killed) have the tightly

curled black or gray wool characteristic of the "Persian lamb," "astrakhan," "krimmer," etc., of furriers. These animals were originally raised in the Karakul and other districts of West Turkestan, but the industry has now spread to eastern and central Europe and even to Africa and America. It is interesting to note that it is here the very

FIG. 135.—Karakul sheep and very young lamb, the latter showing desired tight, uniform, and lustrous curl, evenly distributed all over the body. The ewe is an imported Karakul. (*From Marshall, Heller, and McWhorter, Karakul Sheep.*)

young lambs that are killed for their hides. If a very tight curl is desired the lamb is killed within three or four days of birth; if a more open curl is wanted, the lamb is allowed to live for, perhaps, five or six weeks. As the skin of a three-day-old lamb may bring \$5 or more it would seem that the raising of these animals should be highly profitable.

As an illustration of the methods of fur farming a brief description of those employed in rearing foxes in captivity will suffice.

The skin of the ordinary red foxes (genus *Vulpes*) may be worth from \$5 to \$15 or more. The silver fox, Fig. 136, which is simply a color phase of the red fox, has fur which may be silvery or jet black in color

FIG. 136.—A full furred black fox, *Vulpes sp.*, December fur. $\times \frac{1}{10}$. (From Jones, *Fur Farming in Canada*.)

and is of such beautiful quality that a good hide seldom brings less than \$500 and frequently is worth \$2000; the highest price ever paid for a single black fox skin is said to be \$2900. At the minimum figure,

it is evident, there must be large profits in fox-raising and, in fact, fortunes have thus been made, though the business is a pretty risky

FIG. 137.—The best type of fox ranch. Scale 1 inch = 50 feet. (From Jones, *Fur Farming in Canada*.)

one. Many millions of dollars are now invested in fox farms. Since \$25,000 or more may have to be paid for a single pair of breeders it is evident that a considerable capital is necessary to finance the business.

One of the chief centres for raising silver foxes is Prince Edward Island, Canada; the cold, moist climate and good breeding stock produce pelts of high grade, while the surrounding water makes it easy to capture any foxes that may escape from the pens.

The best location for a ranch is a well-drained piece of woodland, with underbrush beneath which the foxes can sleep without being seen; the trees give shade in summer and warmth in winter.

FIG 138.—Usual type of kennel and pen. Fox seated at entrance. (*From Jones, Fur Farming in Canada.*)

The individual pen is of varying size, usually about 40 feet square, sometimes with a part in which the male may be confined during certain periods when he might injure the females or young. The pen is surrounded by a wire fence 8 or 10 feet high, with an overhang to prevent the foxes from climbing over, and a buried portion or concrete base to prevent their digging beneath to freedom. Around the pen or group of pens is an outer fence. The arrangement of such a ranch is shown in Fig. 137. In the pen is a kennel for protection in

cold weather, made of wood or concrete, with a double wall, filled in with cork or some other non-conducting material. In this warm retreat the young are born during the spring months after a gestation period of about 50 days. One male can be used to mate with several females. One litter of from one to nine pups are born each year, sexual maturity being reached in 10 months.

The foxes are killed in November or December when about eight months old. To obviate injury to the skin, the foxes are often killed either by crushing the chest or by breaking the neck. There is not the slightest excuse for these cruel methods, especially the former,

FIG. 139.—Canadian otters, *Lutra canadensis*. $\times \frac{1}{15}$. (From Jones, *Fur Farming in Canada*.)

since a small quantity of chloroform or of ether could be used at a nominal cost.

Since the value of the skin depends both on the cold climate and on good health, the character of the food is important. Contrary to popular belief, the fox is far from being a strictly carnivorous animal, and a very general diet of meat, fish, mice, rabbits, birds, vegetables, grass, berries, eggs, milk, bread, dog biscuits, etc., is often employed. Like other animals, the fox is subject to certain diseases and the rancher who is raising animals as valuable as the silver fox, needs to make a careful study of the whole business before he begins. Great care has to be taken not only to prevent the escape of the animals from the pens

but to keep poachers from stealing the foxes; for this purpose watchmen, dogs, burglar alarms, electric lights, electric shocking devices, bear traps, etc., are employed.

The natural appearance of the interior of a fox pen is shown in Fig. 138, with a fox at the entrance of the kennel. According to Jones there were 800 silver foxes in captivity in Canada in 1912.

FIG. 140.—The mink, *Putorius vison*. $\times \frac{1}{18}$. (From Jones, *Fur Farming in Canada*.)

Otters, minks and skunks, Figs. 139, 140, 141, though the value of their skins may be stated in cents where that of the silver fox is given in dollars, are all raised profitably under domestication.

Although not a member of the order Carnivora, attention should here be called to the muskrat, *Fiber zibethicus*, Fig. 142, perhaps the most important of our fur-bearing animals, certainly if numbers be considered. When properly prepared, the fur of this animal is very fine and is popular under the name of "Hudson Bay Seal." About 10,000,000 muskrat pelts are sold annually. The muskrat is generally distributed along the water courses of North America. In the salt

marshes along the Chesapeake and Delaware Bays muskrats are protected and collected in large numbers, 50 rats per acre per year being secured in favorable places. They may be fenced in with wire netting and given food and artificial shelter. Not only is the pelt of value but the flesh at certain seasons is sold as "marsh hare" or "marsh rabbit" and is canned. The musk is also sold.

Like other rodents, the muskrat breeds rapidly producing three to five litters of from three to ten or more young each year. They probably breed at the age of six months. Occasionally, the muskrat becomes a pest to the farmer and has to be reduced in numbers.

FIG. 141.—Skunk, *Mephitis* sp. $\times \frac{1}{5}$. The skin of this animal is a "long stripe," or rather wide No. 3.

Another rodent, the largest of our American forms, the beaver, *Castor canadensis*, Fig. 143, is a fur-bearer of considerable importance. Formerly, largely used in the manufacture of beaver hats, it is now chiefly used as plucked fur, in muffs, etc.

The above and many other furs are sold either under their own or a trade name, the latter being given because of popular prejudice against the real animal from which the fur came. In many cases the fur is clipped and dyed out of all resemblance to its original appearance. Some of these names are considered by reputable dealers to be permissible, others are actual misnomers and are given with the intention of deceiving the purchasers. Among the former some of the better known are the following, the actual name being given first, the trade name second: goat (dyed)—bear goat; mink (dyed)—sable mink; opossum (sheared and dyed)—beaver opossum; muskrat (pulled

and dyed)—Hudson Bay seal; rabbit (sheared and dyed)—seal coney; white rabbit—mock ermine; skunk—black marten. Among the actual misnomers for the use of which dealers may be prosecuted are the following: muskrat (pulled and dyed)—seal; rabbit (sheared and dyed)—seal; muskrat (dyed)—mink or sable; white rabbit, ermine; white rabbit (dyed) chinchilla; goat (dyed)—bear; etc.

Ponies, lambs, kids, puppies and cats are used in large numbers in the fur trade.

The subject of furs and fur-bearers is a large one and for further information the reader is referred to special monographs and trade journals.

FIG. 142.—Muskrat, *Fiber zibethicus*. $\times \frac{1}{5}$.

The lions, tigers and leopards, inhabitants of warm climates, though not usually thought of in connection with the fur-bearers, have considerable value in this way, but their destructiveness to cattle or even to human life makes them of more negative than positive value.

Although the carnivora are not very generally used for human food, yet some of them such as bears, seals, etc., are often so used. The skins of certain bears are also valuable and those of certain seals are among the most prized of all furs, as will be noted later. One of the most important uses of some of our smaller carnivora, notably, the skunk, mink, weasel, fox, coyote, and others, is in the destruction of many of our rodent pests, soon to be described. Most of the animals just named are considered by the average farmer to be a nuisance because of the occasional raids that may be made on his inadequately protected poultry, but a few farmers are beginning to realize the value of these carnivora

as rodent destroyers and are taking steps to protect them. Some farmers insist that skunks in particular should be protected by law against skin hunters, on account of their value to agriculture.

Pinnipedia. Seals.—All of the above carnivorous fur-bearers belong to the terrestrial group of carnivora. Of the aquatic forms the

FIG. 143.—The beaver, *Castor canadensis*. $\times \frac{1}{10}$. (From Jones, *Fur Farming in Canada*.)

fur-seal is the most important and is, perhaps, the best known of all the fur-bearing animals, though its fur is so often and so closely imitated that most people cannot distinguish the real thing from its imitations.

The fur-seal, *Callorhinus alascanus*, Fig. 144, has not only been an

important commercial animal but it has been a subject of international controversy, as will be noted below.

The natural history of the fur-seal is interesting and must be understood before the economic problems involved can be handled.

The home of the Alaskan fur-seal (if we call "home" the place where it breeds) is along the rocky shores of the Pribilof and other islands of the Aleutian group. Here large herds of seals assemble for the short summer season, the places of assemblage being known as "rookeries." The males are known as "bulls" and are enormously larger than the females or "cows." The young are known as "pups," so that the popular nomenclature is decidedly mixed. The bulls arrive at the breeding grounds first, from the south, early in May; the height of the season is the middle of July and the southern migration begins in August. As the females arrive they are driven or carried bodily into groups known as "harems." A harem consists of from one to a hundred or more cows, presided over by a single old bull; an average number for a harem might be about thirty. The bulls fight over the possession of the cows, the largest and the fiercest bulls securing the largest number of cows. In these perpetual fights not only are the skins of the bulls torn and ruined, but the cows and pups are often injured and even killed. The young bulls that are not large and strong enough to secure a harem are known as "bachelors," and it is these uninjured and, for breeding purposes, useless bachelors that supply, or should supply, the skins of commerce.

The single young is born soon after the arrival of the seals and the cow is then served by the bull. Many pups are killed as noted above, many die of starvation, and many of hookworm and other diseases. It is probable that the killing of the extra males, say 95 out of every 100, would, by diminishing the fighting, actually increase the prolificness of the herd by diminishing the death-rate of the pups and injury to the cows.

The seals are killed with clubs, after being surrounded by a group of men and driven to a flat "killing ground" where the desirable ones are slaughtered and the rest are allowed to return to the sea. At the close of the breeding season the seals start on their southward journey for the winter which may extend as far south as California. It was during this migration that the most destructive killing of seals by man took place, beginning about 1881-2. This so-called "pelagic sealing"

FIG. 144.—Fur-seals at the Tolstoi Rookery, Pribilof Islands, toward the close of the season, August 23, 1914; bachelors mingling with cows and pups. (After Parker, *Fur Seals of the Pribilof Islands*.)

came near exterminating the herd and causing international war. The reasons for the excessive destructiveness of pelagic sealing were as follows: the seals were killed with spears or guns as they lay sleeping at the surface of the sea; as the sex of the animals thus killed could not be determined until after capture the females as well as the young males were killed. With the death of each adult female not only was the adult killed, but her unborn young and her sucking pup also perished, making at least three deaths for each hide secured. This, of course, could not long continue without a rapid destruction of the herd and pelagic sealing was stopped barely in time to save it.

After the United States bought Alaska she seized and confiscated all vessels caught in pelagic sealing, assuming that seals that bred on our coasts were ours when at sea; this brought on a serious controversy with England that lasted, with more or less danger and bad feeling, for 25 years or more, until the convention of 1911, between Great Britain, Russia, Japan and the United States, prohibited all pelagic killing for a period of 15 years. Possibly at the expiration of this period the time may be extended indefinitely. At about the same time the United States enacted a law prohibiting even land killing for a period of 10 years. This law has caused much criticism by those familiar with the breeding habits of the Alaskan seal, as briefly described above.

The agreement to suspend pelagic sealing is one of the most noteworthy attempts to save a vanishing race of animals by international treaty that we have. The diminution of the fur-seal catch since the early eighties are shown in the figures from the offerings of furs at the London Auction sales and other places; for example in 1887, when the sales were greatest, there were offered (according to P. R. Poland & Son, London) 226,370; in 1897 there were 123,336; and in 1907, 55,914; since the last date they have fallen still lower. According to the same authority the catch of seals in Alaska fell from 122,166 in 1886 to 13,584 in 1910, when killing there ceased.

It is likely that but for the prohibition of pelagic sealing the Alaskan fur-seal would have been exterminated as was the American Bison that, a generation or two ago, roamed our western plains in herds of enormous size and was almost completely destroyed by thoughtless and useless hunting.

The price of seal-skins has varied with the year and the character of the skins, ranging from about \$8 to \$40 each.

The treatment of the seal-skin before it is ready to be made into garments is rather an extended process and, of course, adds to the cost of the finished article.

Rodentia (Glires). Gnawing Animals.—This is a large group of small animals, whose chief characteristic is the possession of sharp, chisel-like incisor teeth, which are particularly well adapted to gnawing. There are never more than two incisors in the lower jaw and usually only two in the upper jaw. The incisors and sometimes the back teeth have persistent pulps which causes them to continue to grow, to make

FIG. 145.—Photograph of skull of woodchuck, showing an upper incisor that had grown in an arc of a circle until it entered the roof of the mouth, after its opposing lower incisor had been broken off. $\times 1$.

up for the wearing away of their cutting surfaces. If an incisor be broken off, the opposite tooth, having no mate to wear against, will continue to grow, in the arc of a circle, until it may cause the death of its possessor, Fig. 145. No canine teeth are present, which leaves a wide space between the incisors and the premolars. While rodents, as a class, are vegetable feeders, some forms, such as the common rats and mice, are practically omnivorous. The integument is usually furry, sometimes hairy and occasionally spiny (Porcupines); the digits end in claws; the cecum is very large; the cerebral hemispheres are comparatively smooth.

This extensive order of more than 1400 species includes the following well-known North American families: Muridæ, the rats

and mice; Sciuridæ, the squirrels; Leporidæ, the rabbits and hares, Castoridæ, the beavers; Geomyidæ, the pocket gophers; and Cœnidæ (Hystrioidæ) the porcupines.

This largest of the orders of mammals is also one of the most important, economically, since it is one of the most destructive of all the animal groups. It is the negative importance, then, that will be chiefly considered here, though some of the species have some positive value to man, as already noted in connection with the fur-bearing animals.

Muridæ. Rats and Mice.—The largest of the above-mentioned families of rodents, both as to numbers of species and of individuals, and by far the most important economically is the family *Muridæ*. Of the *Muridæ* the most important genus is *Rattus*, including the only too familiar rats, whose damage to man each year in the United States has recently been estimated by the Biological Survey to be at least \$200,000,000, or the value of the labor of an army of 200,000 men. Not only does the rat cause this enormous monetary loss, but it is the *known* disseminator of the bubonic plague and some less serious diseases, and is *supposed* to be the carrier of several others; so that a prominent medical man recently stated that he considered the rat the worst disease carrier we know.

The plague was known long before the beginning of the Christian Era, and on several occasions, in Europe, under the name of the "black death" it carried off people by the millions. In 1907 the deaths from plague in India were estimated at 2,000,000. Since rats, as is well known, are common on board of ships, it is very easy to see how the plague has been carried from infected ports to all parts of the world. When it became known that the plague is a disease of rats, carried, on the death of the rat, to man by the rat flea, the problem of plague control resolved itself into the problem of rat extermination. How well this may be done by a vigorous, coöperative effort is illustrated by the successful campaign waged, some years ago in San Francisco and surrounding cities. Incidentally the problem was complicated there by the discovery that the rat fleas were also carried by the ground squirrels, so widely distributed in that part of the country. The methods of extermination of both rats and squirrels will be discussed later.

Three kinds of rats are found in the United States and are generally distributed throughout most parts of the civilized world. Their

scientific names have been frequently changed; those given here are the ones used in the Biological Survey of the United States Department of Agriculture.

The common rat of most parts of the country is the brown or Norway rat, *Rattus norvegicus*, also known as the wharf rat, the sewer rat, the grey rat, the house rat, etc., Fig. 146. Less common are the black rat, *Rattus rattus rattus*, and the roof rat, *Rattus rattus alexandrinus*. The latter two are somewhat smaller than the former, have longer ears and tail and are not so vigorous and aggressive, so that they usually give way before the brown species; they are similar in size and form but are distinguished from each other by the difference in color, the roof rat resembling more the brown rat in color while the black rat is much darker, nearly black. The roof rat is common in some parts of the south.

FIG. 146.—Brown or Norway rat, *Rattus norvegicus*. $\times \frac{1}{4}$. (From Lantz, *House Rats and Mice*.)

Key to Species of House Rats and Mice. (Lantz)

Size, small. Total length of adult less than 200 millimeters. . . . *Mus musculus*.

Size, large. Total length of adult over 300 millimeters.

Ears moderate, when laid forward barely or not reaching eye; tail shorter than (rarely equal to) the length of head and body, darker above than below; color of body normally grey-brown above, whitish below; hind foot 38–46 millimeters (Brown Rat) *Rattus norvegicus*.

Ears larger, when laid forward reaching at least to middle of eye; tail longer than head and body, dusky all around; hind foot 33–37 millimeters. Color blue black above, slaty below (Black Rat) *Rattus rattus rattus*.

Color grayish brown above, white or yellowing white below (Roof Rat).

Rattus rattus alexandrinus.

In habits the three rats are so similar that the following description will apply to all. The common white rats, familiar as pets and as subjects for scientific investigation, are merely albinos, probably of the Norway rat. They are usually mild and gentle in disposition and are not often seen in the wild state. The original home of the rat was probably India or some other part of the Orient; it suddenly appeared in Europe in 1727 and about 1775 it was introduced into America. There are now only two or three States in which it is not known. The average weight of the brown rat is from 1 to $1\frac{1}{2}$ pounds and an animal of that size that occurs in such enormous numbers can destroy an immense amount of valuable property. As has been said the rat is perfectly omnivorous in habits; though it may prefer certain kinds of food, it will when hungry eat anything that can be chewed, and it frequently spoils more than it actually eats.

On the farm they are often a terrible pest. They eat corn when newly planted, necessitating replanting; they eat it from the stalk, for rats are excellent climbers and are able to perform astonishing feats of this kind; they nest under the corn shocks and feed on the corn all winter, in sections where corn is left out all winter for cattle feeding; they eat corn and all other grains in the bin and grainery, unless the latter are thoroughly rat-proofed. The manager of a large cattle ranch in Southwestern Virginia estimated his loss of corn in the shock at 500 bushels in a single season from rats; and many farmers estimate their annual loss of corn in the crib at from 10 per cent. to 25 per cent. After the grain reaches the mill it is seriously injured by rats and mice unless very active preventive measures be adopted.

Poultry is so seriously affected that in some instances farmers have given up the attempt to raise it; chickens nearly ready for market are killed and carried away by rats, the damage being often wrongly ascribed to skunks, minks and other wild animals. Nesting birds, as noted in the chapter on birds, are also seriously injured in some places.

Fruits and vegetables, especially while in transit to market on trains or vessels, are often very seriously damaged. Many instances are reported of serious damage to meat in the farmer's smoke house, and cases are reported of young hogs being killed and eaten by rats. Besides the above, the damage on the farm, by rats in undermining and in otherwise injuring buildings, walls, etc., is often considerable.

In towns and cities the loss is equally great and is probably more

varied; here their favorite haunts are markets, restaurants and other places where food is stored, especially in the neighborhood of docks and wharves. A large milling company of Kentucky estimated its annual loss upon grain sacks alone at \$3000 and in smaller mills it is common to hear the manager estimate his annual loss at many hundreds of dollars.

"In 1898 a large packing house in Chicago had 3360 hams destroyed by rats;" and in the smaller branch offices of the packing houses, where thorough rat proofing has not been adopted, heavy losses to meat are reported.

Commission merchants suffer heavily from rats, which eat all kinds of goods and carry off eggs by the dozen in a single night.

The department stores, especially those that handle food-stuffs, as most of them do, suffer so heavily that most of them regularly employ, by the year, professional rodent exterminators that they pay often as much as \$50 or more a month. Besides eating and spoiling large quantities of food-stuffs the rat does heavy damage in various other ways; for example, numerous fires have been started from rats and mice gnawing matches; buildings have been flooded by rats gnawing through lead water-pipes; expensive china and glassware are sometimes knocked from shelves and broken; bedding, furniture, drygoods and other inedible materials are often destroyed or rendered unsalable.

Few people realize the numbers of rats that are sometimes found in infested regions. After careful and conservative investigation it has been estimated that in towns the normal rat population is about equal to the human, while in rural districts it is much greater. On a rice plantation of 400 acres over 17,000 rats were killed in a single year. In a single raid in a city warehouse often bushels of rats are destroyed. 1700 rats have been destroyed in fumigating a steamship.

Under certain conditions rats have been known to migrate in great hordes, like their relatives, the lemmings; and there is a more or less definite periodic migration from their warm winter quarters in towns and buildings to the adjoining fields, and back again, with the change of seasons.

Being secretive and largely nocturnal in habits there are often many more rats about a certain region than is generally appreciated, and this, added to their remarkable cunning, enables them to multiply with astonishing rapidity.

A rat may bring forth from three to a dozen litters of young a year, with from six to twenty in a litter, averaging perhaps ten per litter. At this rate, and with the females reaching sexual maturity in three or

FIG. 147.

four months, it will be seen how, under favorable conditions, a locality may, in a short time, be simply overwhelmed with the pests, so that the most vigorous remedial efforts must be exerted to stem the tide.

The traps, poisons and other methods of destroying rats are numberless, and many of them are very effective; but here, as in other things, "an ounce of prevention is worth a pound of cure," and it is far better

FIG. 147a.

FIGS. 147 AND 147a.—Street-car posters used in New Orleans during the rat campaign by the U. S. Public Health Service. (After Nelson, from the *National Geographic Magazine*, Washington, D. C., copyright, 1917; by special permission.)

to prevent the breeding of rats or to keep them out of mischief than it is to destroy them after they have begun to be a serious menace.

There are at least two good reasons for protecting food from rats:

obviously to save the food, but also for the reason that well-fed rats breed much faster than those with a scant food supply. There are several ways to starve out the rat: one is to keep all garbage and other

FIG. 148.—Rat-proofing barns and stables by elevation of contents. The baled hay has been raised in this case so as to give rats no place to hide. (After Nelson, from the *National Geographic Magazine*, Washington, D. C., copyright, 1917; by special permission.)

such refuse in rat-proof metal cans, Fig. 147; another is to protect buildings and other receptacles for food-stuffs against the rat. In con-

structing a new building it is comparatively easy and inexpensive to make it rat- or even mouse-proof, and in many cities this is enforced by law; in the case of an old building it is often difficult but seldom impossible to properly rat-proof. In many barns and stables where the expense of rat-proofing the entire building would be prohibitive it is easy to completely cover the feed or grain bins with wire netting; or to pile the bales of hay or sacks of feed on elevated platforms, either supported from the floor as in Fig. 148 or hung from a ceiling that has no rafters along which rats can run. An arrangement such as shown in Fig. 148 not only protects the material but also removes the harbor in which the rats hide and rear their young, one of the most important of the preventive measures of rat extermination.

In rat-proofing a judicious use of concrete and galvanized wire netting will do the work, but both are usually necessary. Many houses are made with rat-proof cellars, but if the cellar windows are not screened rats and mice will soon make their entrance and the concrete walls and floors have been in vain, so far as rodent infestation is concerned. At a very slight expense the windows and doors can be closed with wire netting of about $\frac{1}{4}$ inch mesh. Another frequent point of entry into otherwise rat-proof buildings is through or around drain or other pipes. The openings around all pipes should be tightly closed with a mass of cement as thick as the wall. The lower edge of all outer wooden doors should be covered with a strip of tin or other metal about a foot high to prevent rats from gnawing through.

A frame building with brick or stone foundation, may be made rat-proof by cementing the entire floor of the cellar, screening the windows and filling in the space between the laths and outer boards with concrete to a height of about a foot. Or, a cement wall, starting a couple of feet under ground and extending a foot above ground may be built around the outside wall of the house, as shown in Fig. 149. Porches and small buildings without cellars should be elevated a foot or more above the ground to prevent the harboring of rats and to allow dogs and other rat destroyers to enter. Floors and wooden walks whose timbers are laid directly on the ground are sure to harbor rats. In stables where cement floors are objectionable, wooded floors may be laid directly on the cement. Various methods of proofing corn cribs may be employed. One method is shown in Fig. 150, where is built a concrete wall, sunk about 20 inches in the ground, with a concrete floor, upon

which the house is constructed. The lower part of the slats are covered with wire netting, at the top of which is a belt of metal, about a foot wide, to keep the rodents from climbing over the netting.

FIG. 149.—Rat-proofing an old wooden building in New Orleans. A cement wall sunk in the ground two feet and extending one foot above will prevent rats from harboring in many such structures. (After Nelson, from the *National Geographic Magazine*, Washington, D. C., copyright, 1917; by special permission.)

A cheaper method is to cover the entire floor, beneath the boards, with netting, with the same belt of metal and netting around the sides.

A common method is to build the house on tall posts that are either belted with metal or have a large inverted pan at the top of each post; to be effective the floor should, in this case, be at least 3 feet from the ground. In any case it is obviously important never to leave the door of the crib open and never to lean lumber or farm implements against the walls by means of which rats may climb over the screening. Some farmers prefer to completely cover the crib with wire netting, others to make the wall entirely of concrete, except openings for ventilation. Probably no farmer who has once had a rodent-proof corn crib ever cares to be without this means of protecting his corn. In some

FIG. 150.—Perspective of rat-proof corn crib, showing concrete foundation by dotted lines; also the belt of metal to keep rats from climbing up the sides. (*From Lantz, House Rats and Mice.*)

cases the cost of proofing will be saved in a single year. On almost every farm there are old out-houses, piles of lumber and trash, and many other places that furnish harbors for rats; these should be destroyed or cleaned up.

For those who rent houses that are not rat-proof there are numberless schemes for protecting edible goods from rats and mice, largely by the use of tin and screens and by elevation above the floor. Entire rooms are often lined with wire netting as a place to store easily damaged goods. Foods preserved in tin and glass are, of course, safe from rodents.

While, as has been said, it is much better to keep rats away from

food and not allow them breeding places, it is not possible always to do this, and it is usually necessary to combine these preventive measures, with active measures for their destruction.

Two chief destructive agents are used (besides cats, dogs, etc., to be noted later): traps and poisons. There are numerous types of traps on the market, many of which are effective if intelligently handled. Perhaps the best traps for general purposes are the spring or guillotine traps; some of these are made entirely of metal, Fig. 151, and are easily

FIG. 151.—All metal guillotine or “snap” rat trap. $\times \frac{1}{2}$. (From Lantz, *House Rats and Mice*.)

deodorized by heat or water; others have a wooden base, Fig. 152, and have the advantages of being somewhat cheaper and of being more easily set. These traps kill the victim instantly and are so cheap that they may be set by the dozen, which is obviously advantageous. They can also be placed in the runways of the rats where they often catch rats without being baited. They are very “quick on the trigger” and it is almost impossible for a rat to remove the bait. Various substances should be tried for bait, usually some kind of food that is scarce in the place where the trap is set; for example, where grain is about,

bait with meat, in a meat-shop bait with grain. Vienna sausage, toasted bacon, toasted cheese, raw meat, fish, apple, vegetables, oat-meal, etc., may be tried; if one substance does not tempt the rats, try others. Put the traps in runways and hidden places. It may be well

FIG. 152.—Guillotine or “snap” rat and mouse traps with wooden bases. $\times \frac{1}{5}$.

to wash the traps and handle them with gloves to keep them from smelling of the human hands.

Another type of trap is the wire cage trap, Fig. 153, which has the advantage of catching under favorable conditions, a number, perhaps a

FIG. 153.—Wire rat trap. $\times \frac{1}{4}$.

couple of dozen, rats at one time. Such a trap should be partially covered with boards or sacking and should be baited with some form of bait such as was mentioned above. It is often well to leave the trap open, for a few nights, to get the rats accustomed to going in and out of

it. Sometimes good results can be secured by the use of some form of barrel trap. Fig. 154, 1, shows a barrel with a head of heavy paper tied over the open end; on this paper food is placed for several nights till the rats get the habit of going there for it, then a couple of slits are cut in the paper, which allows the rats to fall into the barrel. A nicely balanced hinged lid may be used, as shown in Fig. 154, 2. If a foot of water be placed in the barrel the rats will be drowned by morning, which will save the unpleasant task of killing them. Various modifications of this trap may be used.

By the use of a small movable wire or wooden pen that may be put around shocks or piles of corn or other grain so that the grain may be

FIG. 154.—Barrel rat traps. 1, with bait fastened to stiff paper cut across. 2, with the bait fastened to a hinged lid that can dip only one way because of a nail at *a*. (After Lantz, *House Rats and Mice*.)

thrown out of the pen, the hidden rats are kept inclosed and can be easily killed by dogs or with clubs.

For destroying rats out of doors or in barns, stables and other houses where the odor of dead animals is not a serious objection, the use of poisons is often the most effective method. In some States the law requires that notice be given before poisons are used, and in all cases extreme care should be taken not only to keep the poison out of the reach of children and other persons, but also to protect dogs and other domestic animals. Various poisons are in more or less common use, besides the numerous special preparations that are sold in packages for this purpose. Some of these preparations seem very effective, others are more or less useless.

Probably the most commonly used poison is powdered white arsenic which is cheap but is not so effective as some of the others. It is used in various ways, the easiest being to rub it into fresh fish or meat, spread it upon buttered bread, or make it into a dough with cornmeal and white of eggs (1 part by weight of arsenic to about 12 of cornmeal).

A better poison is barium carbonate, which may be used in about the same way as the arsenic, except that a larger proportion (1 to 4) of the poison is used in making the dough. Its action is so slow that rats often escape from buildings before death, so that it may sometimes be safely used in dwellings. In the small quantities used for rats it is not usually fatal to domestic animals.

Strychnin (usually as the sulphate) is one of the best poisons for rats but it is so violently poisonous that it should be used with extreme care. Tiny pieces may be inserted in small pieces of meat, or oatmeal or other grain may be soaked over night with strychnin syrup, made by dissolving half an ounce of the sulphate in a pint of boiling water and stirring in a pint of thick sugar syrup.

Phosphorus is used very commonly as a rat poison, but owing to the fact that fires have frequently been caused by its use it is not to be recommended. It is often claimed that certain of the phosphorus poisons "embalm" or dry up the bodies of rats so that they have no odor—this statement is not true of phosphorus nor probably of any other known poison.

In laying poisons for rodents it is important that they be placed well down in the burrows or be hidden so that domestic animals may not get at them; this is particularly true about stables, chicken houses and such places. A very good way to lay poison, so that chickens and other animals cannot eat it, is to put the poisoned food in a small, upturned box and invert a larger box, in the sides of which small holes have been cut, over the smaller one.

For killing rats in ships and sometimes in storehouses and other places fumigation is often very effective. In such places sulphur dioxide, chlorine, carbon monoxide and hydrocyanic acid are the gases most frequently used. Chlorine because of its bleaching properties, carbon monoxide because of its lack of odor, and hydrocyanic acid because of its extreme danger to human life are all objectionable; so that sulphur dioxide is perhaps to be most recommended, though it has some

bleaching properties. By means of special furnaces it is now forced into the compartments of vessels as they lie at the dock and the whole

FIG. 155.—Guards placed on the hawser to keep rats from boarding the ship. These guards are metal discs about two feet in diameter. The spars that keep the vessel away from the dock are similarly guarded. A man is on guard at the gang-plank whenever it is lowered. (After Nelson, from the *National Geographic Magazine*, Washington, D. C., copyright, 1917; by special permission.)

process takes less than half a day and costs a comparatively insignificant sum compared to the benefits derived. At many sea-ports, especially during times of plague, all vessels, or at least all those from tropical

or infected ports, must be fumigated either at the end of each voyage or at certain intervals. At most ports, also, the law requires certain or all vessels to guard all lines leading to shore with metal rat-shields, Fig. 155, to prevent rats from leaving or entering the vessels. While rats are excellent swimmers they are not apt to deliberately jump into the water and swim ashore.

For killing rats in their burrows in fields, along streams, etc., carbon disulphid is often very effective. A wad of cotton or any other absorbent substance is saturated and dropped into the hole, which is then closed with dirt to prevent the escape of the gas; the rats are left buried in the ground.

Various so-called *rat viruses* are on the market that are supposed to cause contagious bacterial diseases among rats. The idea is excellent but so far none of these viruses, according to the Biological Survey, has proved satisfactory.

A number of domestic animals are commonly used to destroy rats, the domestic cat being the most familiar. While an occasional cat is found that is a veritable terror to rats, and many produce dealers and others claim great efficiency for their cats, yet their value as ratters is probably greatly exaggerated; a well-trained fox terrier or some other breed of dog is usually worth many cats, as a destroyer of rats. Ferrets were formerly much used, especially in connection with dogs, to rid houses of rats, but they require experienced handling and are not so commonly used as formerly.

The natural enemies of rats will be discussed in connection with mice, upon which they feed even more than upon rats. As has been said some of these wild animals are often blamed for the destruction of poultry really due to rats.

In order that any campaign against rats may be effective coöperation among the members of a community must be had. If one person wage war upon rats on his property they will swarm over to the neighboring properties and the only way to get extensive results is to make the campaign a community affair and continue it from year to year. By interesting women's and farmer's clubs, boards of trade and other civic societies much may be accomplished. By having the town, county or state place a bounty of a few cents a head (or tail) upon rats the interest of the small boy may be attracted; and if, in addition, a cash prize for the greatest number of rats brought in during a certain

period be offered a much greater activity will probably be secured from both individuals and from clubs and societies organized for the specific purpose of waging war upon this, our most destructive pest.

Lantz (170) gives the following summary of the measures needed for combating the rat and mouse nuisance:

"1. The requirement that all new buildings erected shall be made rat-proof under competent inspection.

"2. That all existing rat-proof buildings shall be closed against rats and mice by having all openings accessible to the animals, from foundation to roof, closed or screened by door, window, grating, or meshed wire netting.

"3. That all buildings not of rat-proof construction shall be made so by remodeling, by the use of materials that may not be pierced by rats, or by elevation.

"4. The protection of our native hawks, owls, and smaller predatory mammals—the natural enemies of rats.

"5. Greater cleanliness about markets, grocery stores, warehouses, courts, alleys, stables, and vacant lots in cities and villages, and like care on farms and suburban premises. This includes the storage of waste and garbage in tightly covered vessels and the prompt disposal of it each day.

"6. Care in the construction of drains and sewers, so as not to provide entrance and retreat for rats. Old brick sewers in cities should be replaced by concrete or tile.

"7. The early threshing and marketing of grains on farms, so that stacks and mows shall not furnish harborage and food for rats.

"8. Removal of outlying straw stacks and piles of trash or lumber that harbor rats in fields and vacant lots.

"9. The keeping of provisions, seed grain, and food-stuffs in rat-proof containers.

"10. Keeping effective rat dogs, especially on farms and in city warehouses.

"11. The systematic destruction of rats, whenever and wherever possible, by (a) trapping, (b) poisoning, and (c) organized hunts.

"12. The organization of clubs and other societies for systematic warfare against rats."

Mice.—Closely related to the rats and associated with them in the minds of all as plagues of mankind, are the various species of mice of which two or three will be noted here. The most familiar of these is the common house mouse, *Mus musculus*, a pest not only about houses and barns but also in the fields. Like the rats, this mouse is

an introduced species from Europe. It is somewhat similar to the rats in habits and owing to its small size it is able to escape from its larger cousins by entering crevices too small for the rats to follow. Although of so small a size it occasionally occurs in such incredible numbers that it does very serious damage, as was recently the case in Australia where, in the summer of 1917, enormous quantities of wheat were destroyed by mice, which suddenly appeared and increased with unbelievable rapidity until they swarmed about the wheat depots by the million.

Owing to inadequate shipping facilities, the wheat sacks were collected in enormous piles at various places, and it was in this sacked wheat that the mice collected and did such serious damage. Photographs were shown where, by gnawing the bottom sacks, the whole pile was caused to collapse into a mass of torn bags and loose grain; in one case more than 6000 sacks of wheat were "Reduced to a Sickening Dump Heap by a Voracious Host."

After trying unsuccessfully various expedients a very simple remedy was worked out as follows: the stacks of bags were surrounded by a double wall made of strips of corrugated iron about 2 feet wide. This wall made a series of narrow, converging runways, whose narrow, open ends opened over deep pits. By hanging empty sacks over the outer side of the outer wall and the inner side of the inner wall the mice were enabled to get into the runways in either going to or away from the stack, but they could not escape from between the two strips of iron and were easily driven through the narrow end of the passage into the pit, where they were killed by asphyxiating gases. By this simple scheme the pest was brought under control. Mice were caught, literally by the ton and by the million. For example it was reported that approximately 500,000 mice, weighing about 8 tons, were captured in four nights at one grain store. A modification of this method might be used in this country where mice become particularly abundant.

Under ordinary conditions, in houses and stores, the house mouse can be exterminated by the systematic use of large numbers of traps, preferably of the guillotine type shown in Fig. 152. They have not the cunning of the rat so that they are much more easily trapped, using the same baits mentioned above for rats. Flour is often a very effective bait for mice.

Of more serious importance to the farmer and fruit grower are the

so-called *field* or *short-tailed mice*, or *voles*, of which there are over fifty kinds known in the United States. For convenience they may be considered in two groups, the "meadow mice," genus *Microtus*, and the "pine mice," genus *Pitymys*, Fig. 156. The latter may be distinguished

FIG. 156.—Upper figure, meadow mouse, *Microtus pennsylvanicus*. $\times \frac{2}{3}$. Lower figure, pine mouse, *Microtus (Pitymys) pinetorum*. $\times \frac{3}{4}$. (From Lantz, *Meadow Mice in Relation to Agriculture*.)

from the former by its closer, smoother fur, its reddish-brown color and its subterranean habits.

The meadow mice make smooth, branching runs on the surface of the ground, beneath the grass and leaves; the winter nest is under ground, the summer nest is a large ball of dried grass on the surface of the ground. These mice are found, especially in open fields, in

most parts of North America, and at times have been known, for some reason, to increase to such an extent as to be a most serious pest. They produce several litters a year, with from 5 to 10 in a litter.

FIG. 157.—Apple tree 5 inches in diameter girdled by prairie meadow mice, *Microtus austerus*. (From Lantz, *Meadow Mice in Relation to Agriculture*.)

The meadow mice are injurious to crops of all kinds, grain, vegetables and fruit. When in especially large numbers their damage is proportionately greater; for example: in 1906–8 a pest of meadow mice destroyed the alfalfa crop over an area of some 18,000 acres in Nevada,

causing an estimated loss of fully \$250,000; had the trouble been handled in its beginning, in the way to be presently described, a large part of this loss might have been avoided.

Another way in which the meadow mice do serious damage is by girdling young trees of all sorts, but especially fruit trees. They gnaw off the bark at the surface of the ground, the girdled area sometimes extending a short distance below the ground, Fig. 157. If the injury be not too great the tree may be saved by piling up the soil over the wound to prevent evaporation until it has time to heal; bridge grafting is sometimes used to save large or valuable trees. While small trees are especially subject to attack, fruit trees of large size are sometimes injured or killed and the damage to a large orchard may amount to thousands of dollars.

Since the remedies for the meadow mice are about the same as for pine mice, they will be discussed after a brief description of the latter group.

Pine mice are common over all of the eastern part of the United States, especially in wooded regions, or in fields, surrounded by timber; they are not found in open plains. As has been said they are burrowing forms, making trails that can only be distinguished from those made by moles by their somewhat smaller diameter and by the occasional small opening to the surface. Because of this burrowing habit they are almost universally confused with and called "moles," and where they are abundant the farmer usually complains of the damage done by moles. It will be remembered that the mole is an insectivorous creature and is, as a rule, a very useful animal to the farmer since it eats grubs and other subterranean insects that birds ordinarily do not see. The pine mouse may even follow along in the burrows made by the mole and it is he who does the damage while the innocent mole gets the blame.

By opening the tunnel and inserting a couple of fingers it is usually possible to tell, by its diameter, whether a mole or a pine mouse made the burrow.

In some sections the pine mouse is a terrible pest; it will follow along a row of newly planted corn and eat every grain for a long distance; sometimes two or three plantings will have to be made before a stand is secured. In the same way potatoes and other vegetables are destroyed. In the eastern United States the pine mice perhaps do more damage to orchard and small trees than do the meadow mice. Since

they girdle the trees beneath the surface of the ground their presence is often not noticed until the trees begin to wither and die. They not only girdle the trees but frequently cut the roots entirely through. While not so prolific as the meadow mice their protected, underground life makes up for their slower breeding.

In destroying field mice there are three distinct lines of attack: traps, poisons and clean cultivation.

In some cases, especially on small areas, an ordinary good type of mouse trap may be used to advantage. It may be baited with some sort of grain or it may be set in the runways unbaited, so that the mice may run over and spring it by accident. Fifteen or twenty traps per acre may be used for several weeks.

In most cases it will probably be better to use poison, especially over large areas and when the mice are very numerous. Strychnine is generally used and various substances are employed as bait. Lantz recommends the following formulæ:

Dry Grain Formula.—Mix thoroughly 1 ounce of powdered strychnine (alkaloid), 1 ounce powdered bicarbonate of soda, and $\frac{1}{8}$ ounce (or less) of saccharine. Put the mixture in a tin pepper box and sift it gradually over 50 pounds of crushed wheat or 40 pounds of crushed oats in a metal tub, mixing the grain constantly so that the poison will be evenly distributed.

Wet Grain Formula.—Dissolve 1 ounce of strychnia sulphate in 2 quarts of boiling water. Dissolve 2 tablespoonfuls of laundry starch in $\frac{1}{2}$ pint of cold water. Add the starch to the strychnine solution and boil for a few minutes until the starch is clear. A little saccharine may be added if desired, but it is not essential. Pour the hot starch over 1 bushel of oats in a metal tub and stir thoroughly. Let the grains stand over night to absorb the poison.

Potato Formula.—Cut sweet potatoes into pieces about as large as good-sized grapes. Place them in a metal pan or tub and wet them with water. Drain off the water and with a tin pepper box slowly sift over them powdered strychnine (alkaloid preferred), stirring constantly so that the poison is evenly distributed. An ounce of strychnine should poison a bushel of the cut bait."

Chopped alfalfa hay may also be used and has the advantage over the grain bait that it does not endanger the life of birds. An ounce of strychnia sulphate dissolved in 2 gallons of hot water will poison 30 pounds of the alfalfa if it has been moistened with water first. The

potatoes have the same advantage over the grain, but they will freeze in cold weather. The dry formula will keep indefinitely while the wet may ferment.

In distributing the poisoned baits a teaspoonful of the grain or a piece of potato is put at each place. If meadow mice are the pest that it is desired to kill the bait is put on the ground in their runways, but to protect the birds, if grain be used, it should be covered with a piece of bark, wood, stone or bush of some sort so that birds will not see it; small boxes, pieces of tiles, tin cans, etc., can be used.

If pine mice are the pest, the bait of whatever kind, may be dropped into the open holes, or holes may be made into the tunnels with a

FIG. 158.—Field mouse skulls taken from pellets found under owl roost in Smithsonian tower, Washington, D. C. (*From Lantz, Field Mice as Farm and Orchard Pests.*)

sharpened stick and the bait dropped in, so that bird life is not endangered.

As in the case of rats, an ounce of prevention is here worth a pound of cure, and this may often be secured by clean cultivation of fields and orchards, thus removing all hiding places and destroying runways and nests. An orchard that is overgrown with weeds and grass is far more often attacked by mice than one that is clean.

One, if not the chief, reason for the great numbers of field mice in our farming communities is the useless and senseless destruction of their natural enemies. Of these enemies some are birds, some are

mammals and a few are reptiles. Although they have already been noted a few of them will be here recalled. Probably the most useful of the natural enemies of field mice are the owls. Fig. 158 is striking evidence of the feeding habits of owls. In 360 pellets of the long-eared owl Dr. Fisher found 349 skulls of meadow mice.

From its habit of living near dwellings the familiar little screech owl is also useful as a destroyer of house mice, as well as field mice, not to mention English Sparrows. With the *possible* exception of the great horned owl, the owls should be rigorously protected. Most of the hawks, herons, cranes, gulls, shrikes, crows, cuckoos, and other of the larger birds are also useful as destroyers of field mice.

Among the mammals that prey on field mice are the skunks, weasels, opossums, raccoons, foxes, wildcats, coyotes, etc., also domestic cats and dogs. Possibly the wild and domestic cats, especially the latter, do more harm than good, but it is likely that in most localities the others much more than pay for the few birds and chickens they destroy by the numberless rodents they eat. This is especially true of the skunks which are inveterate hunters of field mice, grubs and other pests, and very seldom molest poultry yards. The value of their hides causes them to be so persistently hunted that in many sections they have been nearly exterminated. It might be well if the sale of their skins should be prohibited. Black snakes, bull snakes, house snakes and other of our larger snakes are excellent mousers, or even rattlers and should be protected.

Most of the natural enemies of mice mentioned above are also very useful as destroyers of rats. Those that are too small to attack a full grown rat could easily handle a young one and it is thought by some that a skunk or even a weasel will not attack poultry so long as there are rats about the premises.

Farmers are slowly learning to realize that black snakes are very useful animals to have about their barns, some of them claiming almost complete freedom from loss by rats because of the presence of several large black snakes that they carefully guard against injury. The author has talked to several farmers who made this claim. It is often difficult to prevent ignorant hired men (especially negroes) from killing every snake, skunk, weasel, hawk, etc., that they see.

Ground Squirrels.—These serious pests are found in most of the western States, where they cause an annual loss of many millions of dollars,

though their most serious menace is due to the fact that they are carriers of bubonic plague, which they catch from rats. Several cases, some of them fatal, have been traced to ground squirrels, and their destruction is thus seen to be especially important.

Of the numerous species one of the best known is the California, Beechey, or Digger ground squirrel, *Citellus beecheyi*, which is of about the same size and general appearance as the eastern gray squirrel, though not so handsome an animal. It can climb trees for its food, but,

FIG. 159.—Mound of California ground squirrel in oats field. (From Lantz, *Destroying Rodent Pests on the Farm.*)

as its name indicates, it lives on and in the ground, throwing up rounded mounds of dirt from its subterranean burrows, Fig. 159. It eats almost all kinds of vegetable matter—fruits, nuts, plants, grain in the ear and newly planted—but especially grain. It carries its food in its cheek pouches and stores it underground for future use. At times it injures the fruit and nut trees by gnawing the bark. It has been known to carry off large quantities of drying fruit. Besides this, it often does serious damage to irrigation ditches and other waterways.

There are several methods that may be used to exterminate this

pest but, owing to a lack of coöperation among adjacent landholders, they are often not as effective as they should be.

The animal breeds once a year, with from five to eleven in a litter, and though it is a much less rapid breeder than the brown rat it soon multiplies when not actively fought. A hundred or more may sometimes be in sight at one time, in an active colony.

Perhaps the most effective method of destruction is by means of poisons, of which strychnine is to be recommended. Grain is coated with strychnine, as described for killing field mice, and this poisoned

FIG. 160.—Ground squirrels, *Citellus beecheyi*, killed by poisoned green barley heads at mouth of burrow. (From Merriam, *The California Ground Squirrel*.)

bait is scattered about the holes and runs, preferably during the dry season; the animals are thus killed in large numbers. As a protection for birds barley is recommended, the squirrels eat it readily and birds very seldom do. It was found that it was better to use grain that had been merely coated with the strychnine rather than soaked in it, because the cheek pouches, in which the grain is carried, are more quickly susceptible to poison than is the stomach and the food does not have to be eaten before the animal is killed. The cost of poisoning in this way varies, of course, with the cost of the materials and the labor but it is only a few cents an acre, since 100 pounds of the grain will be sufficient for 200 to 300 acres.

Another more expensive method, that may be used to kill any animals, that may escape the poison, is to suffocate them in their burrows with a gas, preferably carbon bisulphid. A tablespoonful of the crude liquid is poured on a corn cob, a piece of dried horse manure or some other absorbent substance and is thrust as far as possible in the hole, just as is done for killing rats in outdoor burrows, and the hole is closed with dirt. If properly done it will kill every squirrel in the burrow, provided all the holes are closed; this method is best used during wet weather when the gas cannot so well escape through pores in the earth. Figure 160 shows a number of squirrels killed by poisoned barley, used while still in the head. Buzzards eat the poisoned squirrels apparently without being injured by the poison.

Under some circumstances traps can be used to advantage in squirrel campaigns, probably the strong guillotine traps mentioned and figured in connection with rats being the best.

Where only a few animals are present they may be shot with rifles or shot-guns; in this case the animals, especially the young, may be used for food, though there is danger, in some cases from handling them, on account of the bubonic plague.

As in the case of field mice there are numerous animals that serve to check the increase in numbers of the ground squirrels and the destruction by man of these natural enemies will result in an increase in the numbers of the pest. Among these animals are the golden eagles, coyotes, foxes, badgers, bobcats, etc.

Planted corn may be protected from ground squirrels and some other animals by coating it with coal tar.

Rabbits.—More than two dozen species of rabbits occur in North America; they fall rather naturally, according to size and habits, into two groups: the larger forms (genus *Lepus*), including the jack rabbits, snowshoe rabbits, etc., are found mostly west of the Mississippi. The smaller forms (genus *Sylvilagus*), generally called "cottontails" occur in all of the States of the Union, Fig. 161.

Rabbits raise from two to four litters a year with an average of four per litter, the rate of breeding varying with the species. They are, as adults, strictly vegetarian, and while they prefer certain foods they will when hungry eat practically any kind of vegetable matter. Since they often do very serious damage to truck gardens, melons, clover, alfalfa, fruit, and nursery trees, etc., their repression is sometimes an

important matter. Their value as food is considerable, however, so that it is often better and cheaper to protect the crops than to try to destroy the rabbits.

In many sections they are so reduced in numbers by hunters that no further efforts are necessary to handle the problem. In the west where the tall, long-legged jack rabbits abound they are sometimes rounded up and killed by the thousands in rabbit drives, by men on horseback aided by dogs. In some States they are protected by law except during a certain brief open season and in a few cases a farmer

FIG. 161.—Cottontail rabbit, *Sylvilagus* sp., in its "form." $\times \frac{1}{10}$. (From Lantz, *Cottontail Rabbits in Relation to Trees and Farm Crops*.)

cannot kill them on his own lands even though they may be seriously damaging his crops. In other States they may be killed at any time.

It is usually only where they have, for some reason, become exceedingly numerous that they are a serious pest. The best known illustration of a serious rabbit pest is seen in Australia, where in a few years they overran the country and were a terrible plague. In a single drive in Australia from 10,000 to 20,000 rabbits have been killed.

Besides the use of dog and gun there are various methods of reducing the numbers of rabbits. One of those is by the use of traps, which are of

various kinds. The familiar box trap with a trigger and falling door is effective. In open country, where hiding places are scarce, the Walmsley tile trap, Fig. 162, is said to be very effective. The figure scarcely

FIG. 162.—Vertical section of a Walmsley tile trap for rabbits. (From Lantz, *Cottontail Rabbits in Relation to Trees and Farm Crops*.)

needs explanation. A couple of lengths of 6-inch tiles lead into a larger T, with a close cover; the whole affair is covered with earth, leaving as natural an opening as possible. The rabbits seek shelter in this arti-

FIG. 163.—A tile trap in use, beneath a wire fence. (From Lantz, *Cottontail Rabbits in Relation to Trees and Farm Crops*.)

ficial hovel and are taken out by removing the lid from the T; a dog at the other opening will prevent the escape of the rabbit there, or a sharpened board may be pushed into the ground to close that exit.

Such a trap will last indefinitely and may be located under a fence, Fig. 163, or in some other spot that cannot be plowed up.

Under some circumstances it might be necessary to resort to poisoning, in which case about the same methods would be used as already described, observing the same care to avoid poisoning birds and domestic animals. Apple twigs may be coated with strychnia and used as bait with little or no danger to birds.

It is often cheaper to protect crops against rabbits than it is to trap or kill the animals. In the case of trees which are particularly apt to be injured during snowy, winter weather when other food is scarce, it is necessary to protect the lower parts of the trunks. This is done by either painting the bark with some substance poisonous or distasteful to rabbits or by surrounding it with some material to keep the rabbits from getting at the bark. Various washes have been used with greater or less success; one of those that seems to be fairly effective is the common lime-and-sulphur spraying mixture. This may be applied to the trees with a whitewash brush and is a fairly successful protection against rabbits and meadow mice; some users claim that one application will last all winter. Perhaps the best material to use to keep the rabbits away from the trees is one-inch mesh, galvanized wire netting 18 inches wide. This is cut in pieces of sufficient length to loosely, surround the trees; it may be kept from touching the trees, and thereby allowing the rabbits access to the bark, by short sticks. If a finer mesh be used the trees will be protected against mice also. Corn stalks, wood veneers, gunny-sacking, etc., may also be used, though they have the objection that they serve as insect harbors, if not removed in the spring. In large orchards all of these mechanical protectors are rather expensive, either to buy or to attach or both. Feeding rabbits in winter to protect orchards has been successfully tried. Corn, cabbage, turnips, or the prunings of the trees may be scattered about the orchards for the rabbits, and mice, to eat when other food is scarce.

To protect small gardens and nurseries and even small orchards a wire netting of $1\frac{1}{2}$ inch mesh and 24 to 30 inches wide may be used to fence out rabbits. Two feet is high enough and the other six inches may be bent outward as a ground wire to prevent rabbits from burrowing under the fence; of course snow-drifts may allow rabbits to get over such a fence.

Pocket gopher. Geomys bursarius, Fig. 164. This animal is found in all of the states west of the Mississippi and in several of those east of that river. It is very destructive to crops and trees and is often a serious pest. It also does serious damage by the mounds of dirt and

FIG. 164.—Mississippi Valley pocket gopher, *Geomys bursarius*. $\times \frac{1}{3}$. (From Lantz, *Directions for Destroying Pocket Gophers*.)

stones which it throws out of its burrow, and by burrowing in the banks it causes leaks in the irrigation canals.

It may be destroyed by about the same methods that have been described for pine mice and ground squirrels, coöperation among adjoining farmers being necessary to any great success.

FIG. 165.—Section of a portion of tunnels of a gopher colony. *a*, mounds of loose soil; *b*, laterals leading to mounds, usually closed with earth; *c*, main runway, usually clean. (From Lantz, *Directions for Destroying Pocket Gophers*.)

Probably strychnia poisoning is the best method of extermination; the same formulæ may be used as given above for field mice; the bait should be placed in the main runways, Fig. 165, *c*. Carbon bisulphid

may be used in damp weather as in the case of ground squirrels. Traps may sometimes be used to advantage, either the ordinary steel trap, buried in the floor of the main runway, or some form of the special gopher traps that are on the market. In irrigated and other suitable districts the burrows may be flooded with water and the gophers thus run out of their holes can be readily killed with dogs, clubs, etc.

Rodents as Food.—As noted above, rabbits are extensively used as food both in America and elsewhere and hence should not be entirely exterminated since, in moderate numbers, they do little harm to the

FIG. 166.—Porcupine, *Hystrix cristata*. $\times \frac{1}{10}$. (From Jordan and Heath, *Animal Forms*, after Brehm.)

farmer. The flesh of the jackrabbit, except the young, is not very desirable but most of the rabbits furnish excellent food. In Australia they were formerly, and probably are still, canned in large numbers and exported.

Squirrels are also extensively eaten, but owing to their smaller size and less abundance, in most places, they are of less importance as an article of food than rabbits. As noted above, the ground squirrels are used for food and might be an important article of commerce but for their connection with the bubonic plague.

Muskrats, whose importance as fur-bearers has been mentioned in connection with the carnivorous animals, to which group they do not,

of course, belong, are also used for food, and efforts are being made to extend their use, under the name of "marsh hare" or other trade names.

Woodchucks, *beavers*, *porcupines*, Fig. 166, *guinea pigs* and other rodents may also be eaten but, with the exception of the last named, are not sufficiently numerous to be of much economic importance, in most localities. Even rats and mice are eaten in many countries, but are not likely to become popular among Caucasians, though they have been eaten during sieges when food was very scarce.

FIG. 167.—Two-toed sloth, *Choloepus didactylus*. $\times \frac{1}{6}$. (From Ingersoll, *The Life of Mammals*, after Sanborn, N. Y. Zool. Soc.)

Edentata. Sloth, Armadillos, Anteaters.—These animals are found almost entirely in South America, though the Armadillo is found in the extreme southern part of the United States, and related forms inhabit the eastern hemisphere. As indicated by the name they are either without teeth in the adult condition or have imperfect teeth—without roots or enamel. The incisors and canines are rarely present.

Three families of Edentates are recognized: the *sloths* (Brady-

podidæ), Fig. 167; the *American anteaters* (Myrmecophidæ), Fig. 168; and *armadillos* (Dasypodidæ), Fig. 169.

FIG. 168.—The great ant-eater of Brazil, *Myrmecophaga jubata*. $\times \frac{1}{16}$. (From Ingersoll, *The Life of Animals*, after Beddard.)

Economically this is an unimportant order. The great anteater or ant-bear may reach a length of 7 feet; in spite of its size its food

FIG. 169.—Armadillo, "Peludo," *Dasypus sexcinctus*. $\times \frac{1}{10}$. (From Ingersoll, *The Life of Animals*, after Sanborn, N. Y. Zool. Soc.)

consists of ants which it captures by means of a long slender tongue. It is used to some extent by the natives as food.

The sloths are arboreal forms that move about with the deliberation that might be expected from their names. They are vegetarians and, except for some possible use as food, have no special economic value.

The armadillo is represented in Texas by one or two species. The nine-banded armadillo, *Dasypus (Tatusia) novemcinctus texanus*, Fig. 169, is a curious armor-covered little animal whose body is about 18 inches in length. It defends itself by vigorous use of its large claws, rather than by rolling up into a ball as is commonly said. It is largely, though not entirely, insectivorous and hence is useful to man. It is

killed by the thousands annually, and is made into the well-known Armadillo baskets by removing the soft parts and binding the tail around to the mouth to serve as a handle. Doubtless it will sooner or later be exterminated by this ruthless slaughter.

The armadillos are also used as food and are said to be very palatable.

FIG. 170.—The gorilla, *Gorilla gorilla*. $\times \frac{1}{25}$. (From Hegner, *College Zoology*, after Flower and Lydekker.)

Primates. Monkeys, Apes, Man, Etc.—This order, though it contains the so-called “highest” of the animals, is of comparatively little economic importance unless we consider man’s importance to himself.

Most of the Primates are arboreal animals, living in the warmer parts of the world. Their limbs are usually prehensile because of the fact that the pollex and hallux are opposable to the other digits. There are almost always five digits ending in flat nails instead of sharp claws. The clavicles are well developed and the orbit is completely surrounded by a bony rim. There are nearly always two thoracic teats, and one young is usually produced at a birth. Some of the Primates, like the lemurs, are small and somewhat dog-like in form, others like the orang-utan and the gorilla, Fig. 170, are larger and more man-like in appearance. Many, like the common monkeys, Fig. 171, have a long prehensile tail that is largely used in climbing; others like the orang-utans, gorilla, and chimpanzee are tailless. Owing to the oppo-

sability of the hallux to the other toes, which enables the foot to grasp objects just as the hand does, the Primates below man (whose hallux, of course is not opposable) are sometimes called quadrumana, four-handed forms.

As has been said this order is of comparatively little economic importance. In many parts of the tropics various species of monkeys and even young gorillas are eaten and are said to be excellent. Since a skinned monkey is so like a human child it is possible that stories of cannibalism may have often arisen from the eating of these lower Primates.

FIG. 171.—Monkey (macaque), *Pithecus* sp. $\times \frac{1}{6}$.

In some places monkeys are a considerable pest, since they travel about in herds and may be very destructive to fruits and other property.

Many harrowing stories have been written about attacks of gorillas upon man, but these are probably exaggerated, as some of the best authorities state that the gorilla will not voluntarily attack man. Doubtless if cornered and compelled to do so it will, like almost all animals, defend itself; and since a large gorilla weighs 500 pounds and is strong in proportion it will be easily imagined that an unarmed man would be absolutely helpless in such a conflict.

Ungulata. Hoofed Mammals.—The representatives of this order are now frequently grouped into three orders: The *Artiodactyla* or

even-toed forms; the *Perissodactyla* or odd-toed forms; and the *Proboscidea*, the elephants. Besides these another related group, the *Hyracoidea*, not true ungulates, includes the small oriental animal, the "coney," mentioned in the Bible.

The ungulates are usually large animals whose digits end in horny hoofs. They are herbivorous and are generally covered with hair or bristles, rather than with fur. The canine teeth are usually absent or rudimentary and the back teeth are adapted for grinding.

The artiodactyla include most of the game animals and the domestic forms that are used for food, such as the deer, sheep, cattle, goats, pigs, camels, giraffes, hippopotami, etc. Most of these even-toed

FIG. 172.—Stomach of ruminant opened to show internal structures. *a*, œsophagus; *b*, rumen; *c*, reticulum; *d*, psalterium; *e*, abomasum; *f*, duodenum. (From Hegner, College Zoology, after Flower and Lydekker.)

forms are known as *ruminants* from their habit of eating vegetation rapidly and later regurgitating it from a storage pouch or *rumen* and then chewing it thoroughly for digestion in the other parts of the stomach, Fig. 172. The hog is the most familiar of the non-ruminating artiodactyla. The perissodactyla include the horse, ass, zebra, tapir, rhinoceros, etc., none of whom are ruminants.

Most of the ungulate animals are so familiar that no further description will be necessary.

The most important of the ungulates are, of course, the ordinary domestic animals, but of these but little need be said here, since libraries have been written upon the different aspects of this important subject.

The United States is the greatest meat-producing and meat-consuming country in the world. In the huge packing houses of

Chicago and elsewhere the handling of enormous quantities of beef, pork and mutton has been developed into a real science. Every part of the animal is used, in the larger plants, the former waste products being converted into various by-products, such as fertilizer, glue, combs, buttons, gelatine, plaster, hair, tallow, soap, perfumery, glycerine, poultry-food, candles, oleomargarine, etc. The conversion of the hides into leather is an important aspect of the cattle industry.

Horse.—The ordinary uses of the horse are too familiar to need description; like the dog the horse has been a friend and servant of man from very early times and has been used in many ways both in peace and in war. In some countries it has also been used for many years, as food, and its use in this way is now very general, though there is still a strong prejudice against horse flesh in many places. It is said that in 1629 a man in France was executed for eating horse flesh on a Saturday in Lent; the meat is now largely eaten in France and other European countries and is even exhibited for sale in some American markets. There is, of course, no reason why horse meat should not be just as good as that of any other animal.

Elephant (Fig. 173).—Two species of elephants are usually described, the African and Indian. These huge, thick-skinned (pachyderm) animals are familiar to all. They are almost hairless, with tiny eyes and huge waving ears. The muscular trunk or proboscis, with the nasal openings at the tip, is prehensile and is used by its possessor for securing food and thrusting it into the mouth, and for many other purposes for which hands are commonly used. There are no canine teeth, but a pair of upper incisors become greatly elongated to form the curved tusks. They are 8 to 10 feet or more in height and may weigh five tons or more.

The Indian elephant is more commonly domesticated, and may be easily tamed and trained, in a few months. It has been used in the Orient for thousands of years, in battle, in parades, for carrying goods, piling lumber, etc. It seems to be an unusually intelligent animal; for example, it exhibits remarkable judgment, while lifting a huge log on its tusks, in calculating the centre of gravity of the log so that the two ends, often of unequal diameters, will balance each other.

Wild elephants are captured in pits and corrals, trained decoys being often employed.

Besides as a beast of burden the elephant has great economic

importance as a source of ivory, and the huge tusks that may be useful to him in his natural environment are the cause of his destruction, in enormous numbers, by man, 9000 to 12,000 being killed annually for the ivory trade. A medium-sized tusk weighs 60 pounds; the largest size 200 pounds.

The flesh of the elephant is used as food in some regions, the trunk and feet being considered the best. The feet are said to be cooked by burying them in the earth and building a large fire on top of the ground.

FIG. 173.—African elephant, *Loxodonta africanus*. $\times \frac{1}{60}$. (From Hegner, College Zoology, after Beddard, from Baker.)

Camel.—Two main species of the genus *Camelus* are found in the Orient; the two-humped Bactrian camel of the Asiatic plateaus, and the one-humped Arabian camel or dromedary. The former is thickly haired and is adapted to the cold of high altitudes; both are adapted to life in desert places by the possession of wide soft feet; tightly closing nostrils (as a protection during sand storms); a mass of stored food in the hump or humps; and particularly, by the possession of tightly closing water cells in the walls of the rumen and reticulum of the stomach, in which 15 or 20 quarts of water may be stored, upon which, it is said, the animal may live for nearly a week. It is even reported that hard-pressed travelers have been saved from

death by killing their camels and drinking the water still stored in the water-cells of the stomach. Each water cell is a small pocket with the opening closed by a sphincter muscle to hold in the water. "One celebrated traveler mentions the case of a camel that had been dead for ten days, and yet had no less than three pints of not unpleasant water still remaining in its stomach."

After the flesh of the hump has been reduced by a prolonged fast it may take three or four months to be replaced.

Camels have been domesticated for long ages and are known, at present, only in the domestic state. Various races are bred and, like horses, are adapted for different uses, chiefly as bearers of heavy loads and for rapid travel as saddle animals; a pack animal may carry 600 pounds or more at a speed of two to three miles an hour; a saddle animal is said to be able to cover a distance of 100 miles in a day. The use of the "ship of the desert" in caravans is too well known to need further discussion. They are also of value to their possessors for their hair, which is woven into cloth, for their milk that is largely used as a food and to some extent for their flesh, which is occasionally eaten. The value of camels is about that of horses. At the time of the gold rush to California, in 1850, some camels were tried, unsuccessfully, on our western deserts; they were later allowed to run wild.

Belonging to the same family (Camelidæ) with the camels are the Llama and Alpaca, which have been domesticated for centuries by the Peruvians. They are both smaller than the camel. The former is used as a beast of burden, the latter is now extensively bred in South Africa for its wool, which is so long, sometimes, that it reaches the ground.

American Bison, Bison bison (Fig. 174).—This magnificent animal (commonly called the buffalo), as mentioned above, once roamed the plains of the western United States in countless numbers. It had been used by the Indians from time immemorial, apparently without appreciable diminution in numbers, but with the advent of the so-called "civilized" white man, armed with firearms, its numbers rapidly diminished until now, except for a few hundreds of captive individuals, cared for in private ranges and elsewhere, this king of American animals, shown on our new five-cent pieces, is practically extinct. "Buffalo" robes that were cheap, a generation or two ago are now no longer on the market. It was said that many of the settlers killed the bison and

used nothing but the tongue, and many were killed purely for sport, the carcass being left untouched on the plains. This wanton slaughter was a disgrace to the American people, and probably but for the public spirit of the members of the American Bison Society and other individuals the race would now be as extinct as the passenger pigeon.

Hippopotamus and Rhinoceros.—These huge pachydermatous forms are used to a considerable extent by the natives of Africa as food, the flesh being like coarse beef.

FIG. 174.—The American bison, *Bison bison*. $\times \frac{1}{25}$. (From Hegner, *College Zoology*, after Beddard.)

Deer.—The various species of the deer family (*Cervidæ*) are among the most useful of our native animals, and were formerly of great economic importance, before their numbers were reduced by indiscriminate slaughter. Venison in medieval Europe and in the early days in America was the common meat of the table, while now it is seldom seen except at frontier points in the United States and Canada. It is one of the most easily digested of foods and hence would be invaluable for invalids. According to tables published by the Scientific American venison requires one hour for digestion, as compared to one and one-half hours for raw eggs, three hours for mutton and five hours for pork or veal.

Besides their value as a source of meat, deer are also important be-

cause of their hides and their horns, not to mention their usefulness as beasts of burden, to be discussed later.

The value of the hides for leather varies with the size and the species of deer. In olden times elk-hide trousers were frequently worn and were said to last several generations. The American Indians, in some sections, still make moccasins, coats and other articles from deer skin. Many thousands of deer-hides were formerly sold each year in England, but the trade has now largely disappeared.

In most species of deer (except a few forms like the caribou or reindeer), only the males have horns; these are solid outgrowths of the frontal bone that are shed each year after the mating season and are grown again as the next mating season approaches. These hard, solid horns are used in various ways: for making "elk-horn" handles for knives and other implements, and for making gelatin and size (used in the manufacture of cloth). Formerly it was a prominent source of ammonia, which for that reason, is still sometimes sold under the name of "hartshorn." India and Ceylon were formerly, and perhaps still are, the chief sources of supply for deerhorn and hundreds of thousands were killed annually.

With the advance of civilization the ranges of the various deer become more and more restricted, in this country, until now it will be necessary to domesticate them if they are to be saved in sufficient numbers to be of commercial value.

According to Lantz deer raising could be highly profitable if the game laws could be changed (as they have recently been in a few states) to allow the sale of venison from private estates, just as the meat of other domesticated animals is handled. It is, of course important that deer and other animals be protected in the wild state; but that a man who buys a pair of deer and raises a herd in an inclosure should not be able to sell their meat, where and when he pleases, is absurd. One great advantage in raising deer over the raising of cattle is that they may be kept on almost any kind of rough, mountain land that is useless for any other purpose. There are hundreds of square miles of waste mountain lands in the United States that could be fenced and used for deer ranges, just as the level lands and grassy mountains are used for cattle.

The largest of the deer family is the moose, *Alces americanus*, Fig. 175, a magnificent animal as large as a horse, whose head is frequently

seen in the homes of the wealthy and is recognized by the widely spreading, *flat* antlers and the curiously shaped muzzle. The moose can be raised under domestication and becomes tame and affectionate. It's chief use is as a beast of burden and it is easily handled and driven.

FIG. 175.—The Alaska moose, *Alces americanus gigas*. This is the largest of the deer family and reaches the size of a large horse. (From Osgood, *The Game Resources of Alaska*.)

It is swifter than the reindeer and has such endurance that it has been known to draw a sleigh 234 miles in a single day.

The elk or Wapiti, *Cervus canadensis*, Fig. 176, is the largest of the round-horn deer and is next to the moose in size. It formerly ranged over almost the entire United States and part of Canada. Its

venison is perhaps the best of all the family especially at the time the "velvet" (the soft covering of the newly formed horns) is shed; it is better if allowed to hang a few days before it is eaten.

The elk is particularly well adapted to domestication because of its fine size, polygamous habits and ability to live on otherwise worthless land. It breeds as fast and requires less care than domestic cattle.

FIG. 176.—Rocky Mountain wapiti or elk, *Cervus canadensis*; buck in foreground, doe in background; after the moose the largest of our deer. (From Lantz, *Raising Deer and Other Large Game Animals in the United States*.)

It is already successfully raised at several places and could be raised equally well in many other localities. If the laws of the state will not allow them to be sold to advantage they could, in many places, be raised in small numbers for home consumption.

It is mainly in times of heavy snow that the elk have to be given other food than that which they get for themselves. Alfalfa is perhaps

best, with a little oats and corn; they must, of course, have plenty of water; also salt.

The enclosure can be fenced with five-foot woven wire, which is usually high enough; but uncastrated males four or five years old must be strongly fenced. A given enclosure will support about as many elk as it would support cattle. Young stock can be bought for breeding purposes for \$100 or less each. The bucks are docile at most times, but during the breeding season they often get very savage and dangerous, and fatalities have been caused by them. The males not needed for breeding may be castrated, which not only makes them gentle but improves the meat, just as it does with cattle and other domestic animals.

Adult males average 700 to 1000 pounds in weight; females somewhat less.

A smaller form that may be successfully raised under domestication is the Virginia deer or white tailed deer, *Odocoileus (Caracicus) virginianus*, the commonest of our deer. Like other deer it is polygamous, one male to ten or twelve females being sufficient for breeding purposes; this makes it possible to castrate most of the males for the same reasons that were given for castrating the elk bucks; though not so large, the bucks of this species are often very dangerous during the rutting season, which is November. The does breed at 17 months and have a gestation period of seven months. The first birth is single; after that twins are usually born. They eat grass, weeds, leaves, acorns, chestnuts, in fact, almost anything; like the elk they must have salt, and, of course, water.

It is probable that besides the above species almost any of the deer family could be successfully and perhaps profitably raised under domestication.

Reindeer or caribou are represented in northern North America, according to Lantz by two groups, the large, wild, woodland caribou, *Rangifer caribou*, and the less important, barren-ground caribou, *R. arcticus* Fig. 171. These species, so similar to the European reindeer, *R. tarandus*, have never been domesticated, though there seems to be no reason why they should not be; and the enormous herds still at large in Newfoundland would supply unlimited stock.

In 1892 the first domesticated Lapland reindeer were introduced from Siberia into Alaska by Dr. Jackson of the Bureau of Education.

The deer were loaned to mission stations where Eskimos were trained to care for them, the superintendents of the stations reporting to the Bureau. Since 1894 the government has appropriated money to continue this work, and in 1910 Lantz estimated there were not less than 23,000 reindeer in the herds. At the end of five years a number of young deer equal to the number loaned each mission is to be returned to the

FIG. 177.—Barren Grounds caribou, *Rangifer arcticus*. $\times \frac{1}{16}$. (From Ingersoll, *The Life of Animals*.)

government. At the end of each year of faithful service each apprentice is given two deer so that in five years he can start in business for himself, but he is then allowed to kill for meat and skin only the surplus of males, and he is encouraged to raise deer for carrying United States mail, passengers and freight. He is not allowed to sell female deer except to the Bureau of Education in order that the business may not get out of the hands of the Eskimos.

Through the efforts of Dr. Grenfell, Lapland reindeer have been introduced in Labrador and Newfoundland with great success, and it is to be hoped that this will lead to the domestication of a part of the vast herds of American reindeer there running wild in a more or less useless state.

Sirenia. Sea Cows (Fig. 178).—This order contains a small number of rather large aquatic mammals belonging to the genera *Manatus* and *Dugong*; the members of the former genus live along the Atlantic coasts of tropical and sub-tropical America and Africa; the latter genus is found along certain oriental seacoasts.

The sea-cows are probably so named because of the cow-like shape of their muzzle and because of their habit of browsing upon sub-aquatic vegetation after the manner of cattle feeding upon grass. The Sirenia are devoid of posterior appendages and the anterior limbs are modified into flippers for swimming. At the posterior end of the body is a bluntly pointed tail. The bones, unlike those of the somewhat similar whales, are heavy, to enable the animal to sink to the bottom where it feeds upon sea weeds and other aquatic plants. According to some observers it never entirely leaves the water, at least in its natural habitat.

The Florida manatee was nearly exterminated until a fine of \$500 was levied for killing it; it is now thought to be increasing in numbers. It may be caught alive to fill highly paid orders for exhibition purposes. The flesh of the Sirenia forms a very desirable food and in the orient the dugong is considered a royal dish. It is somewhat like pork and the fat is boiled out and used as we use butter. It may be dried or salted and keeps well. The South American monks consider the manatee and other aquatic mammals as fish, which permits their being eaten during fast days when flesh would be prohibited. The skin is used in making leather. The manatee is occasionally caught in the West Indies and sold for food.

Except for their comparative rarity the Sirenia would be a group of considerable economic importance.

Cetacea. Whales, Dolphins, Etc.—The classification of this order is variously given by different authors; by some these forms are all included in one order—Cetacea, with various families; by later writers two orders are used—*Odontoceti*, the toothed whales, and *Mystacoceti*, the whalebone whales.

FIG. 178.—Manatee or sea-cow, *Manatus*, sp. $\times \frac{1}{12}$. (From Ingersoll, *The Life of Animals*.)

As a matter of convenience the single order, Cetacea, will be used here, and one or two members of each of the above two groups will be discussed from the economic standpoint.

The whales are wholly aquatic in habits and hence are fish-like in form. The anterior appendages are developed into flippers, the pos-

FIG. 179.—Skull of Greenland whale, *Balaena mysticetus*, showing whalebone. $\times \frac{1}{80}$. (From Hegner, College Zoology, after Sedgwick, from *règne animal*.)

terior appendages are usually entirely wanting and the pelvic girdle is vestigial. The tail is flattened vertically and is divided into right and left flukes, and by its vigorous up-and-down motion propels the animal with the speed of a steamship. The body is practically devoid of hair and is surrounded, beneath the skin, by a layer of fat (blubber)

FIG. 180.—The dolphin, *Delphinus delphis*. $\times \frac{1}{30}$. (From Hegner, College Zoology, after Sedgwick, from *règne animal*.)

that serves to keep the animal warm in the cold water in which it usually lives. The nostrils are in the form of spiracles on top of the head, from which a jet of moist breath causes the appearance of "spouting." The eyes are very small and no external ears are present. In the toothed whales numerous teeth are present in the adults, in the whalebone whales teeth are present only in the embryos, the adults

being provided with numerous frayed-out plates of *baleen* or whalebone, suspended from the upper jaw, Fig. 179 and serving to strain out small organisms from the water that the whale gulps into its enormous mouth and then forces out through this whalebone strainer.

Among the smaller members of the toothed forms are the dolphins Fig. 180, and porpoises, of which there are several species, extending

FIG. 181.—Sperm whale, *Physeter macrocephalus*. (From Hegner, College Zoology.)

from 5 to 15 feet in length. They are familiar to most people who have taken ocean trips, from their habit of “playing” about the bows of a vessel.

The sperm whale, *Physeter macrocephalus*, Fig. 181, is the largest of the toothed whales, reaching a length of 75 feet.

FIG. 182.—Sulphur-bottom whale, *Balaenoptera musculus*. (After Rabot, *Whale Fisheries of the World*.)

The largest of the whales is the sulphur-bottom, *Balaenoptera musculus*, Fig. 182, which, according to Hegner, reaches a length of 95 feet and weight of about 294,000 pounds; the late F. W. True, an authority on the Cetacea, gave the maximum length as somewhat less than this. At any rate this is the largest living animal, and perhaps the largest that has ever lived, for while some of the extinct reptiles were longer, they were probably not so bulky as this whale. Another large

whale is the Greenland, an Arctic form yielding valuable oil and whale bone.

The *finbacks*, Fig. 183, and *humpbacks*, Fig. 184, are the forms most commonly killed at present.

FIG. 183.—Common finback whale, *Balaenoptera physalus*. (After Rabot, *Whale Fisheries of the World*.)

The killer whale, *Orca orca*, is a voracious form, 20 feet or more in length, that is very destructive attacking all marine animals, even the largest whales.

The narwhale, *Monodon monoceras*, is an Arctic form, one of whose upper teeth is prolonged into a twisted horizontal tusk 5 or 6 feet in length.

FIG. 184.—North American humpback whale, *Megaptera nodosa*. (After Rabot, *Whale Fisheries of the World*.)

There are numerous other species that more or less closely resemble those mentioned above.

One of the first and most important of the uses to which whales have been put is the production of sperm oil. Oil has been used for illumination and other purposes for ages, probably since the seventh century.

It was first obtained from whales that were stranded upon the shore, then from whales that were hunted at sea. The Norwegian whale-hunters are said to have landed on Newfoundland before the discovery

FIG. 185.—Photograph of finback whale, *Balaenoptera physalus*, taken at Provincetown, Mass. (From True, *The Whalebone Whales of the Western North Atlantic*.)

of America by Columbus, though this statement may not be true. The height of the sperm oil business was reached about 1846, when in the

FIG. 186.—A whale steamer. (After Rabot, *The Whale Fisheries of the World*.)

United States, more than 700 vessels and 40,000 people were engaged in the collection of 12,000,000 gallons of oil per year, valued at \$8,000,000; whalebone was also collected.

The discovery of petroleum and the diminution in the number of whales almost killed the business, so that in 1902 the whaling fleet

of the United States consisted of eight steamers, Fig. 186, and 30 sailing vessels; and the total output of the world was about 3,000,000 gallons per year.

After a decade of inactivity the whale fishery experienced a considerable revival, headed by the Norwegian hunters so that an annual catch of 20,000 whales was estimated about 1912. Numerous companies were formed in different countries with stations in nearly every part of the colder regions of the world. Along the northern coast of Norway the killing of whales was prohibited for a term of years because of the claim of the cod fishermen that it injured their business. The most prolific stations have been those of the Antarctic Seas, where whales were found in great numbers; in 1911, 10,000 finbacks and humpbacks were killed in the Antarctic in the region of South America; in the same year

FIG. 186a.—Norwegian whaling station at Green Harbor, Spitzbergen. (Photograph by Hoel, after Rabot, *Whale Fisheries of the World*.)

the total production of oil was estimated at 102,000 metric tons, and large quantities of whalebone, guano and other valuable products were also obtained.

This business does not require large capital and when fortune smiles and good fishing grounds are found the profits are enormous. "In two years a company with a capital of 910,000 francs, installed at South Georgia, twice distributed a dividend of 130 per cent. besides adding a portion of the profit to various reserve funds and increasing the company's resources 60 per cent." (183).

The oil is obtained by boiling down the blubber, 30 tons or more of which may be taken from one whale; from 10 to 100 barrels of oil may be obtained from a single whale, depending on the species and size. At the present time the flesh and other portions remaining after extraction of the oil are made into fertilizer, guano.

FIG. 186b.—Return to port after the chase, towing a whale on each side. (After Rabot, *Whale Fisheries of the World*.)

Spermaceti is a wax-like solid that is obtained from a peculiar kind of clear whale oil found particularly in the sperm whale. This oil is found in various parts of the body but especially in a large cavity on the dorsal side of the head, between the skull and the integument. The oil is given a certain rather complicated treatment and from it is extracted the spermaceti, formerly used largely in the manufacture of candles.

Baleen or whalebone, as noted above, occurs as long, fringed masses in the mouth of various species of whalebone whales. It is rather loosely attached to the sides of the upper jaws, Fig. 179, 187, and 188, from which it is easily dug out with axes and spades. The *bowhead* and *right whales* supply the best whalebone, and as a large bowhead may fur-

nish as much as 2000 pounds of baleen together with a hundred barrels of oil, to say nothing of the guano and other products, the value of such a catch is considerable. The record amount of baleen in one animal, according to Stevenson (185), is 3100 pounds.

The slabs of baleen may be 10 to 12 feet long, about a foot of the base being imbedded in the jaws.

FIG. 187.—Photograph of the head of a sulphur-bottom whale, *Balaenoptera musculus*. Baleen station, Newfoundland. (From True, *The Whalebone Whales of the Western North Atlantic*.)

The lower edges of the slabs are frayed out into a kind of coarse, hair-like structure that is clipped off and used in making brushes, etc.

When the whale is killed the jaws with the attached baleen are hauled upon the deck of the ship, Fig. 188, where the whalebone is removed, cut into slabs and thoroughly washed and cleaned of any flesh or foreign substances. On the voyage back to port these slabs are further split up, cleaned and tied into bundles of a size convenient for handling,

FIG. 188.—Raising a side of whalebone into a ship. (*From Stenenson, Whalebone, its Production and Utilization; after a painting in New Bedford.*)

FIG. 189.—Bundles of whalebone as received at the factory. (From Stevenson, *Whalebone, its Production and Utilization*.)

Fig. 189. These bundles are landed at the most convenient port; San Francisco is the chief port for the Arctic fisheries. At the factories, those of America being principally in New York City and Boston, the baleen is split into long slender strips, suitable for whips, dress stays, etc. In the early days of whale fisheries the valuable properties of baleen were not appreciated and but little of it was brought to port. It is supposed that the first importation into England was in 1594. The price has fluctuated like that of most commodities, varying from 10 cents a pound, in early times, to \$5 or \$6 a pound in recent years.

Many substitutes for whalebone are on the market, but none of them combines the various useful characteristics of the real article.

Ambergris, a curious light solid, sometimes found floating on the sea, or lying on the shore, was long a mystery. It is also found in the intestine of the sperm whale; it is probably a morbid secretion, comparable, perhaps, to the gall stones of other mammals. It is mainly used in making perfumery, but was formerly used as a nerve stimulant, in medicine and for other medicinal purposes. Lumps worth as much as \$10,000 have been found in a single whale. It is worth from \$5 to \$10 per ounce.

Other ways in which the cetacea have greater or less economic importance might be discussed. For example they are largely used as food, especially by the Japanese; their offal, as has been said, is made into fertilizer; the tusk of the narwhale consists of valuable ivory; the teeth of some species are valued by some peoples; ribs and other long bones are sometimes used by semi-civilized peoples in house-building; the hides of porpoises are made into leather. Altogether this small group of large animals has a very considerable economic value.

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